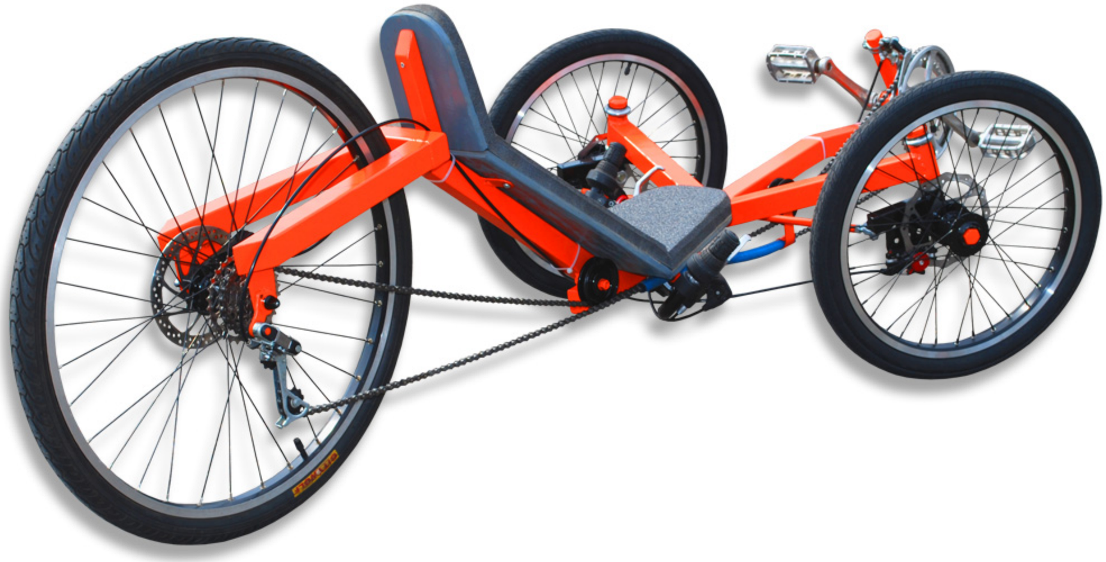
Build the Warrior Racing Trike

Another Atomic Zombie™ Extreme Machines Adventure



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Introduction

The Warrior Racing Trike takes performance and looks to all new heights. With triple disc brakes, under seat steering, and a general racing attitude, the Warrior would easily pass for an expensive production import. Built using inexpensive bicycle components and steel tubing, the Warrior weighs in at only 43 pounds, and has perfect handling and braking characteristics. There is not one single machined part on the entire trike, and everything can be built using only a basic welder, hand drill, and angle grinder!

The low slung recumbent seating is not only comfortable; it also gives the rider an aerodynamic advantage, as well as the ability to deliver your human powered energy directly into the cranks. On a recumbent trike like the Warrior, you never have to slow down for the corners, and because you are stable on three wheels, hill climbing is a breeze. The steering geometry is easy to build and set up, and there is no tire scrub or “bump steer”, so your ride will be predictable and smooth all of the time.

The Warrior Racing Trike uses commonly available 20mm hubs, so there are no hard to find or overly expensive components needed. The frame is completely made of square steel tubing, and everything else on the Warrior Trike can be found at bicycle shops or hacked from scrap bicycles. The building process is designed to allow anyone with a Do-It-Yourself desire to finish his or her own version of the Warrior without requiring previous bike building experience or specialized tools and skills.

With plenty of room behind the seat for a battery pack, the Warrior lends itself well to become a street worthy electric trike, and with a full fairing, would make an excellent velomobile.

Welding Health Hazards

All welding processes produce fumes and gases to a greater or lesser extent. Galvanized steels produce added fumes from the vaporized zinc coating. Fumes from welding galvanized steel can contain zinc, iron and lead.

Use precautions, including high-velocity circulating fans with filters, good ventilation, air respirators and fume-extraction systems.

Making the Rear Fork Legs

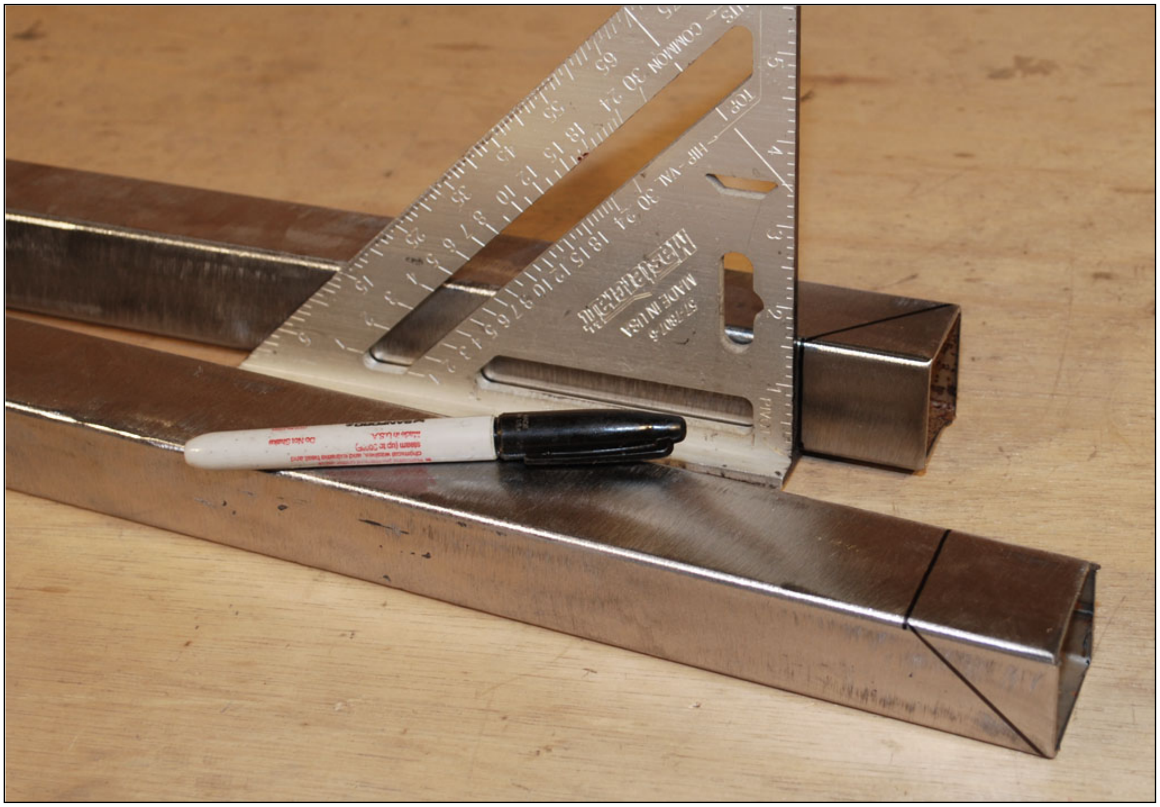

Figure 1 – Cutting the two rear fork leg tubes

Most of the Warrior Trike frame is made from 1.5 inch mild steel square tubing with a 1/16 inch wall thickness. This tubing can be ordered from any steel supplier and is very easy to cut and weld. Steel suppliers like to rate tubing wall thickness using a gauge number, so 1/16 wall tubing will be called 16 gage tubing, and although there is a slight difference between the two, your best bet is to tell them you want a length of 1.5 inch square tubing with a wall thickness as close to .0625 inch (1/16) as you can get. If you are a heavy rider (over 300 pounds), then you should ask for the next size after that, which will most likely be 14 gage tubing, or .078 inch wall tubing. Round tubing should be avoided for this project, as it will yield a more flexible frame, and make angle cutes much more difficult to get correct.

To make building this trike easier, and to help eliminate errors that might occur from making angled cuts that are slightly off, the build will progress from one step to the next, often using the last step as a guide for the next. For instance, we will begin by creating the rear forks, which will then be used to hold up the rear seat tube at the correct angle for welding. By working on one part at a time, you can easily make alterations to the plan or not worry so much of your bicycle components are not exactly the same as mine. You could even make radical design changes, such as using a 20 inch rear wheel instead of a 26 inch wheel, and still end up with a perfectly functional trike. I also recommend that you read over the entire plan before starting, and try to look ahead a few steps to see why cuts or welds are done in certain orders.

The first two tubes you will need to cut will form the legs of the rear forks, which hold the rear wheel to the top of the rear seat tube. Start by cutting two 17 inch piece of the 1.5 inch square tubing. This length (17”) is a bit longer than necessary so that the angles can be derived as the part is being made. The two rear fork leg tubes shown in Figure 1 will also have 45 degree slices cut at one end of the tube. This 45 degree cut gives the completed rear forks a more streamlined look.

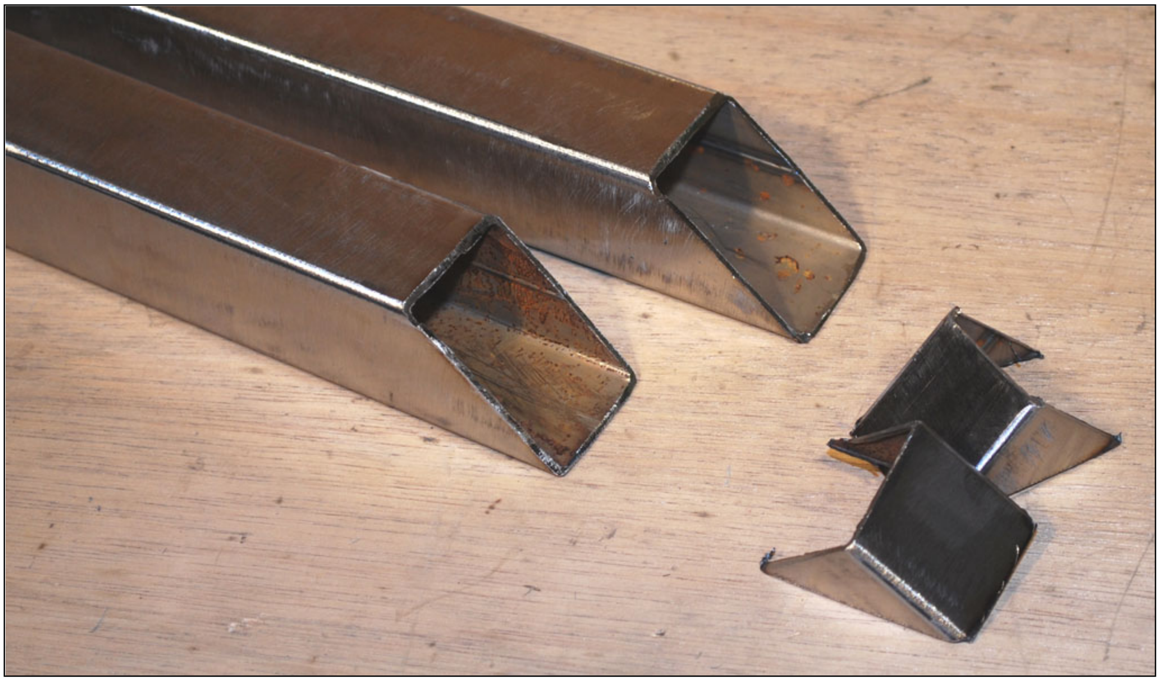

Figure 2 – Cutting the 45 degree slices form the fork legs

After marking one end of each of the fork legs using a 45 degree square (shown in Figure 1), cut away the slices using whatever method you normally use to cut metal. I use a 3/32 cut-off wheel (zip disc) in my angle grinder for all cutting, but a hacksaw will also work if you are not yet comfortable or highly accurate with your angle grinder. The two 45 degree slices are shown cut away from the fork legs in Figure 2. These scraps will later serve as material for tubing end caps, so don’t toss them away.

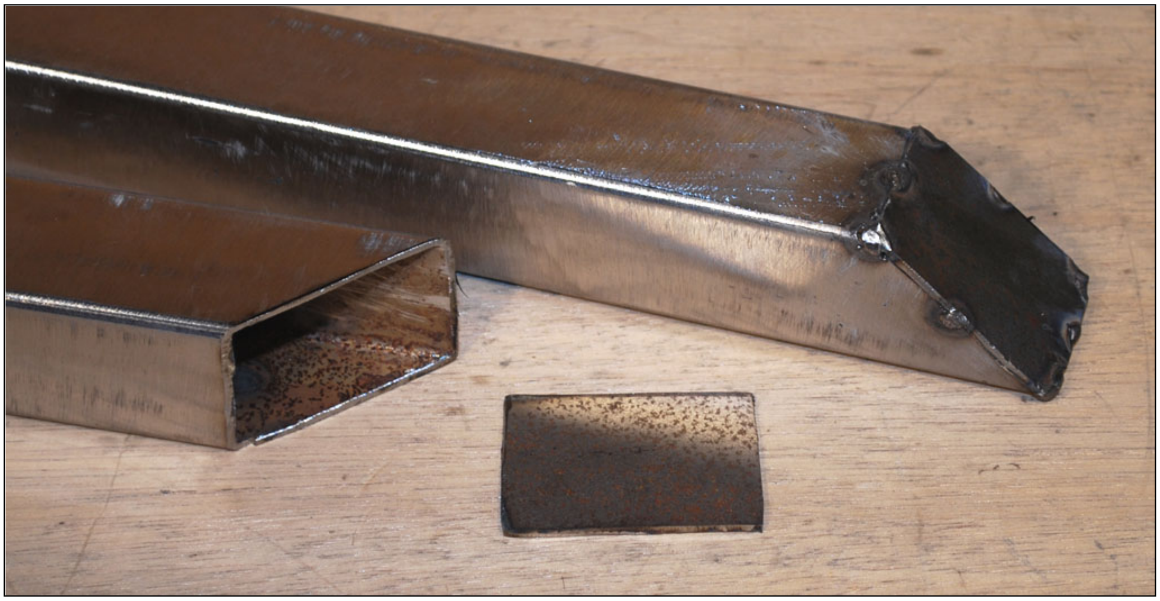

Figure 3 – Cutting metal to make the end caps

The open ends of the fork legs need to be capped off in order to make the tubing rigid and to seal the inside from the elements. Without the end caps, the tubing would not be rigid enough for your frame, and it would certainly not look very professional. End caps can be made by cutting some 1/16 wall sheet metal or even by cutting a section of the 1.5 inch tubing you are using to make the Warrior frame. The two scraps removed from the ends of the tubing earlier are not long enough to make these caps due to the extra length needed to cover the 45 degree cut. The caps will need to be 1.5 inches by 2.25 inches to cover the holes. Figure 3 shows one of the end caps tack welded to the fork leg, ready to be welded all the way around.

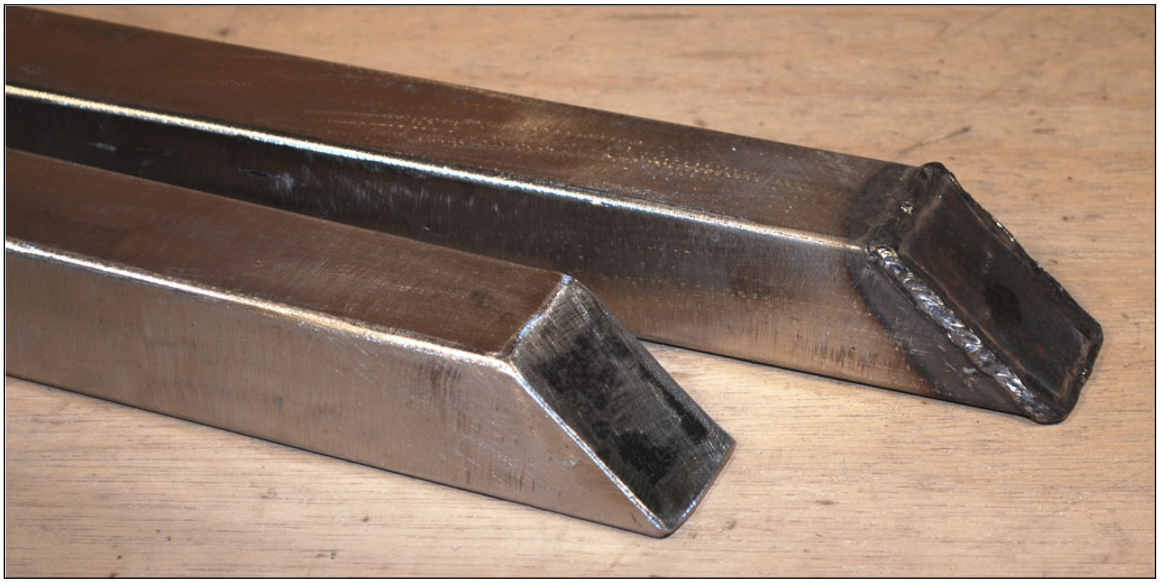

Figure 4 – Cleaning the tubing end caps

The end caps are first welded all the way around as shown in Figure 4, and then ground clean using a sanding disc (flap disc). A flap disc is a grinder wheel that has multiple sandpaper strips attached to it, and it does great work when cleaning up a welded area. Non-critical welds that do not see much stress can be safely ground flush, but those under high stress should not be ground unless you are confident with your welding abilities. I will only show non-critical welds ground smooth throughout this entire plan.

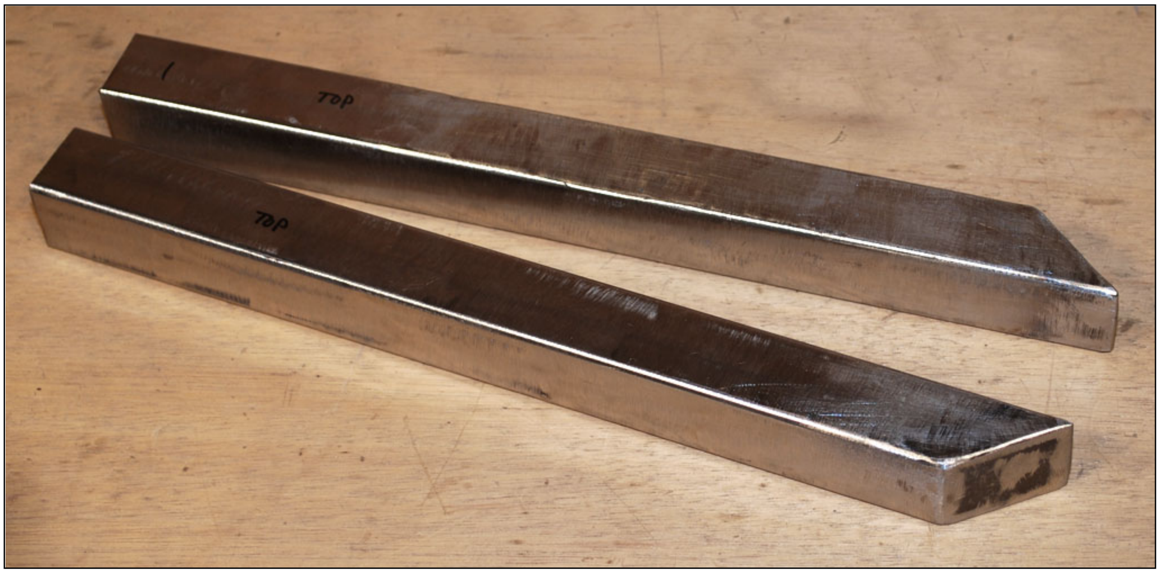

Figure 5 – The capped read fork leg tubes

Weld and clean both end caps on both fork leg tubes as shown in Figure 5. Chances are, you will find small pits and gaps after using the flap disc to grind down the area, and so a few spot fills with the welder will be needed in order to make a perfect seam. Body filler can also be used, but that is cheating!

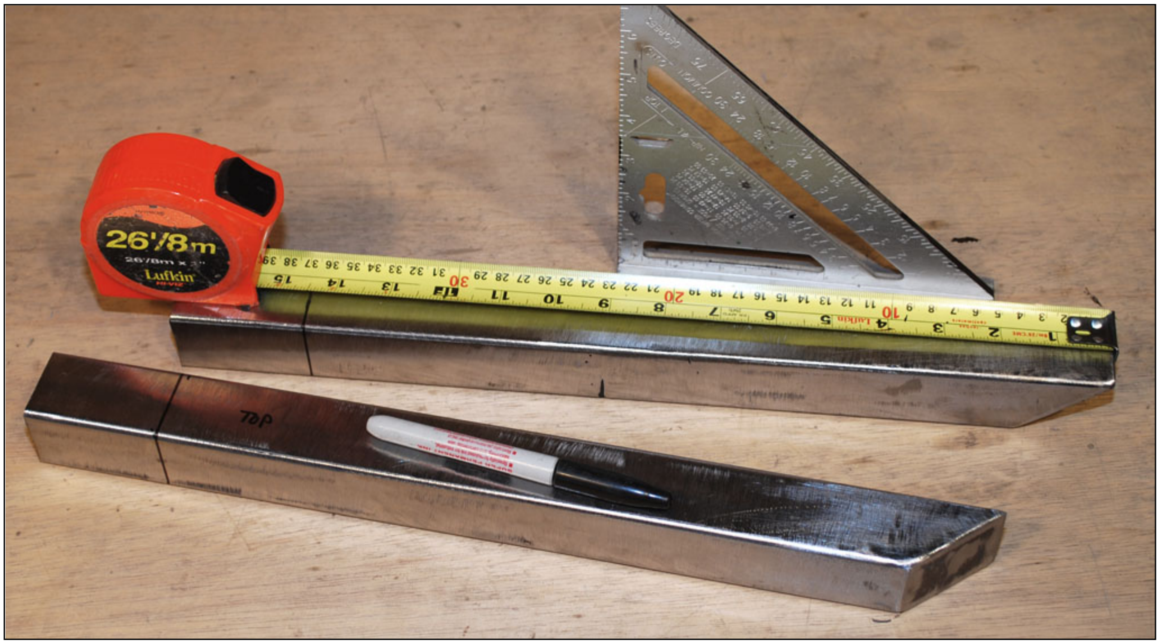

Figure 6 – Mark the fork legs to a length of 14.5 inches

The rear forks must spread outwards equally on each side from the frame towards the rear axle as can be seen later in Figure 26. Rather than trying to make these subtle angles from a drawing and hope they are accurate, we will use a system that ensures that the angles are correct without even knowing what they are. I use this method as much as possible, as it eliminates mistakes and complex cutting. Start by marking a line 14.5 inches from the longest end of each fork leg as shown in Figure 6. Using a square, trace this line around the tubing, and check to ensure both fork legs have the line in the exact same place as they are held together.

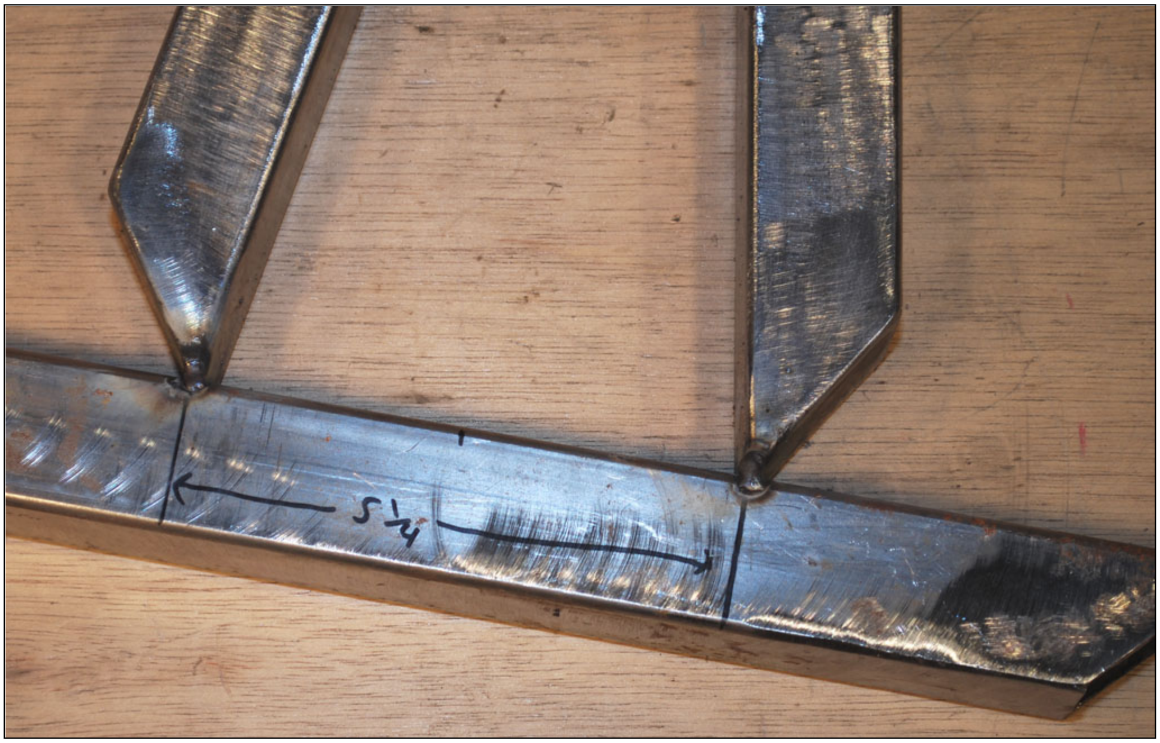

Figure 7 – Tack weld the fork legs 5.25 inches apart

To properly position the axle between the fork legs, a distance of 5.25 inches needs to be between the dropouts. As shown in Figure 7, tack weld the tips of the fork legs (on both sides) to some straight metal edge so that they are exactly 5.24 inches apart. A piece of 1.5 inch tubing is perfect for this job, and can simply be cleaned up later after breaking off the tack welds.

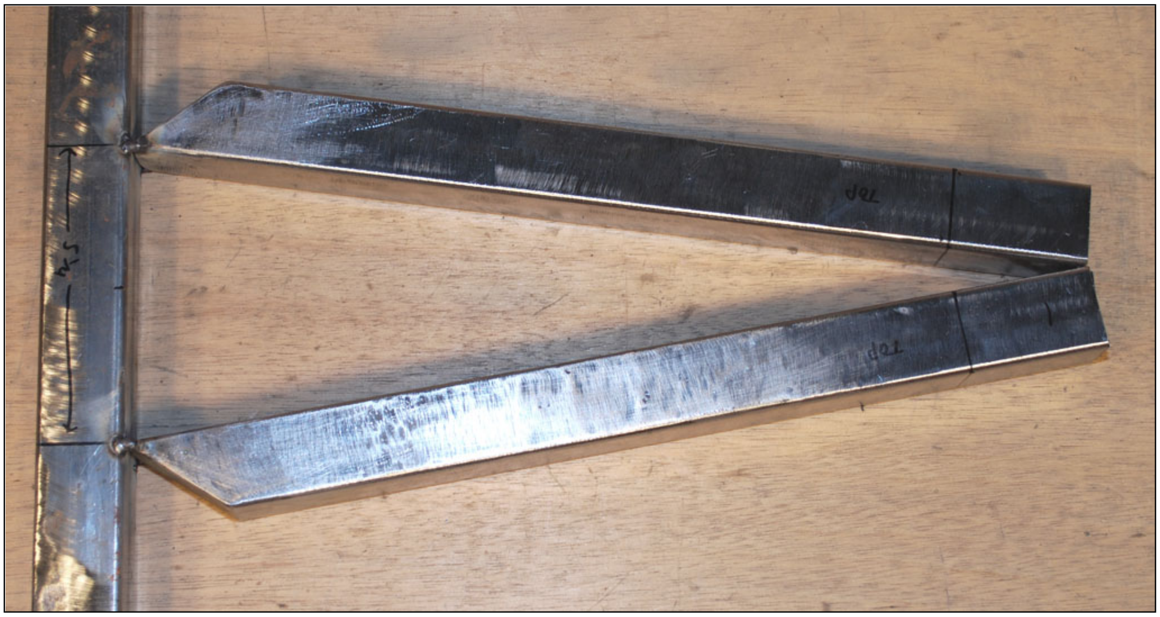

Figure 8 – The tops of the fork legs must form a triangle

To ensure that both fork legs have been tack welded in place at the same angle, press the legs together until the tops meet each other perfectly as shown in Figure 8. This forms a perfect triangle, and places both fork legs at the same angle on both sides. An adjustable square can be used to compare each side, or you can trace a line on paper, and then flip the assembly for comparison.

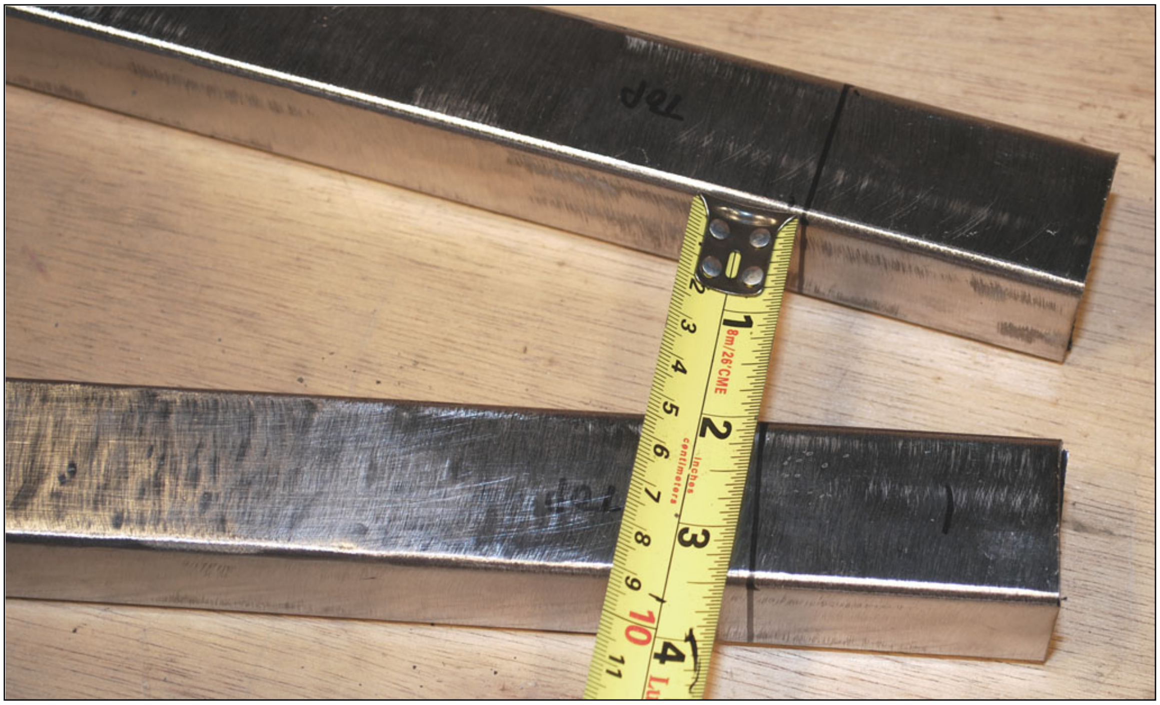

Figure 9 – Spread the fork legs to 2 inches at the line

Place a tape measure at the inside line on each fork leg as shown in Figure 9 and then carefully spread them apart until they stay at the 2 inch mark. With the tack welds working as a hinge, it should be easy to pry the legs apart by placing your fingers into the tube to force them into position.

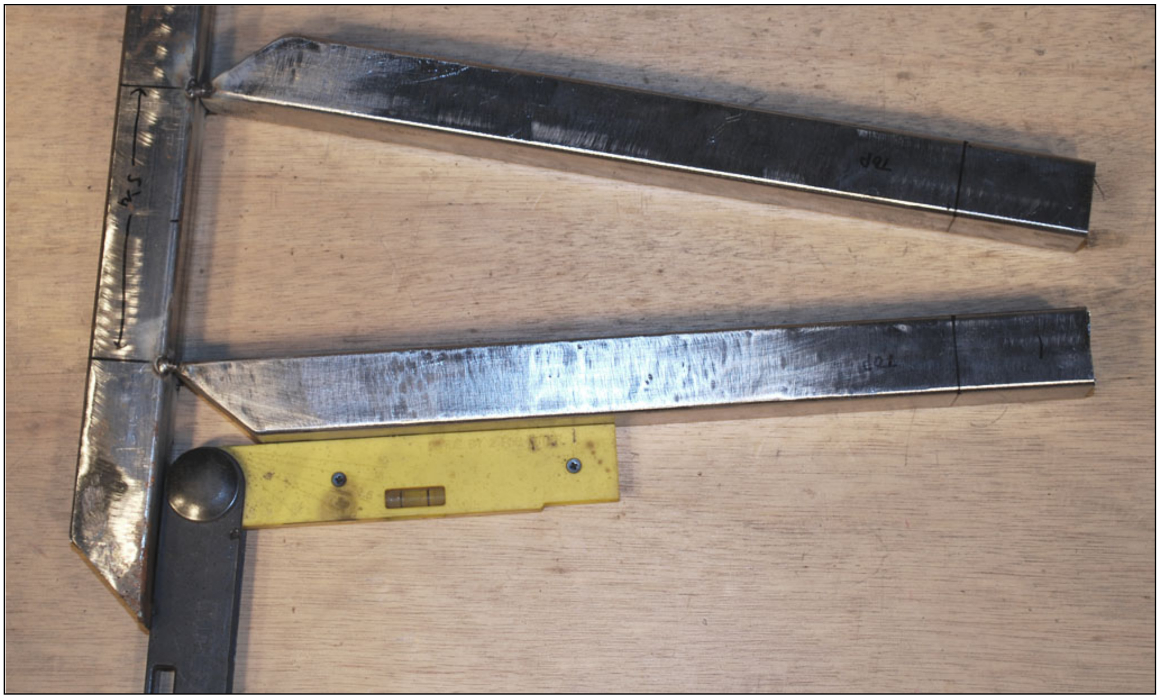

Figure 10 – Comparing the two leg angles

The two legs will likely pry apart at the same exact angle, but a quick check using an adjustable square or even a bit of paper to trace on would be a good idea. To check with an adjustable square, set it on one side and then just compare the other as shown in Figure 10. If you can’t see any error by eye, then it is close enough.

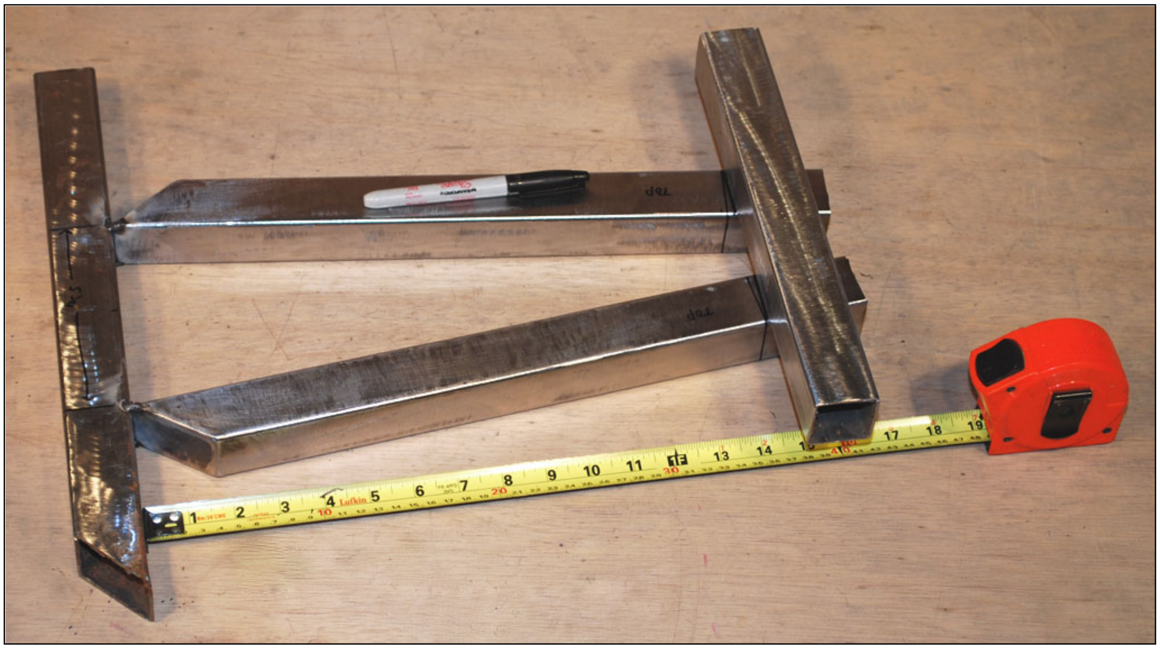

Figure 11 – Setting up a guide to mark a line

The fork legs will be trimmed across the top of the line so that they form a parallel line to the piece of metal the legs are tack welded to. Figure 11 shows a guide tube being used as a straight edge to mark the line. Another way to check the fork leg angles is to measure the distance from the straight edge to the bottom tube; it should be the same on both sides as the straight edge sits across the outer points of the two lines.

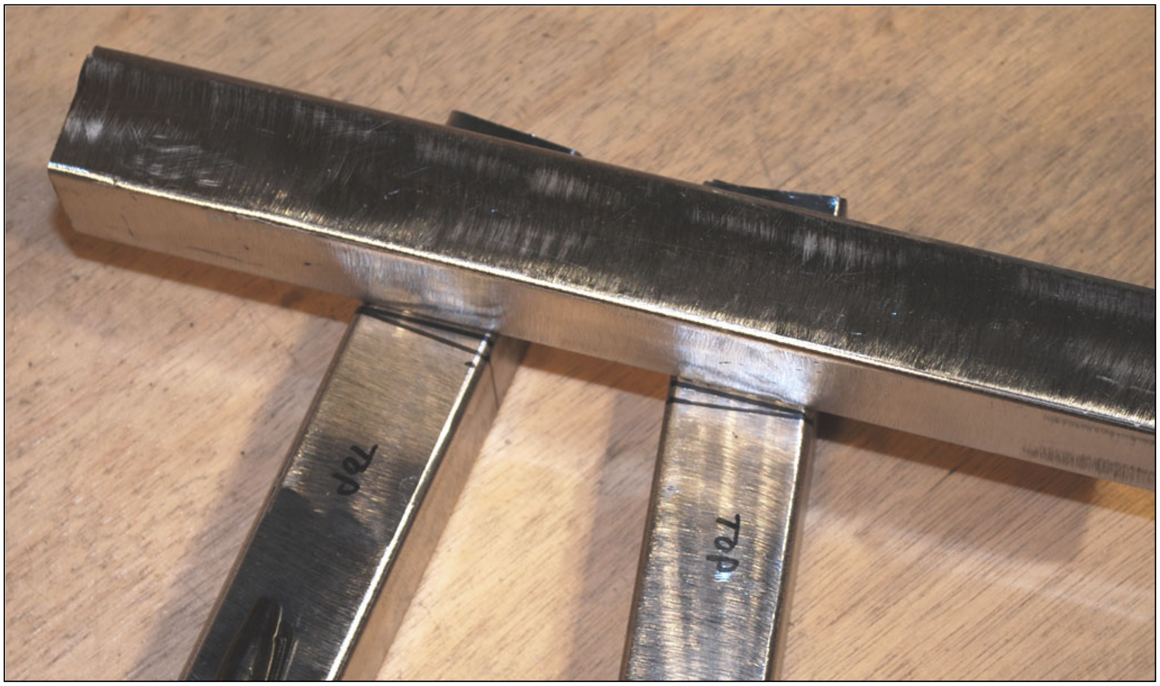

Figure 12 – Positioning the straight edge to draw the cut line

Figure 12 shows the proper position for the straight edge as well as the new cut line drawn parallel across both fork legs. Remember that the distance between the fork legs at the line should be 2 inches (show back in Figure 9). Flip the fork legs over and draw the same cut line on the other side as well.

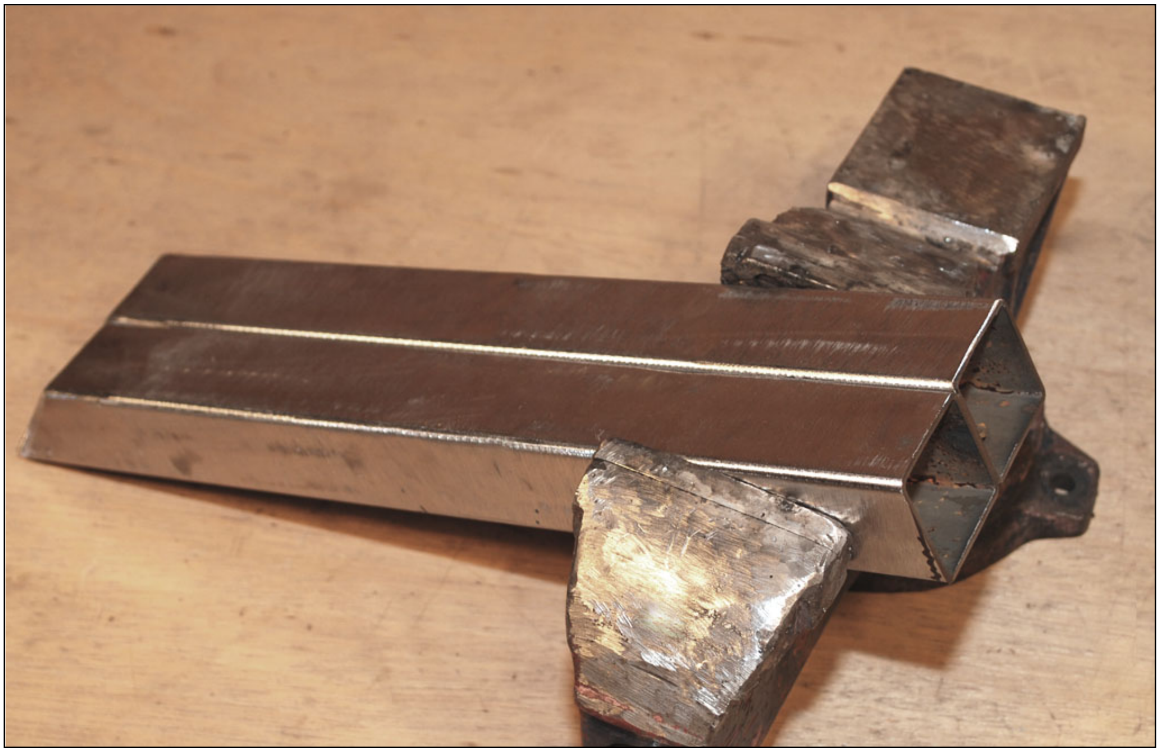

Figure 13 – Making both legs equal after cutting

To cut the fork legs, bend them back and forth to break them free of the tack welds, and then finish the inside lines by joining the points with your square. After cutting both legs, place them both together so the tips line up and then grind any differences where you just cut. Placing the parts together in a vice as shown in Figure 13 makes it easy to fix any small errors in size. I use a flap disc (sanding disc) for this work, as it lessens the chance of taking away too much metal.

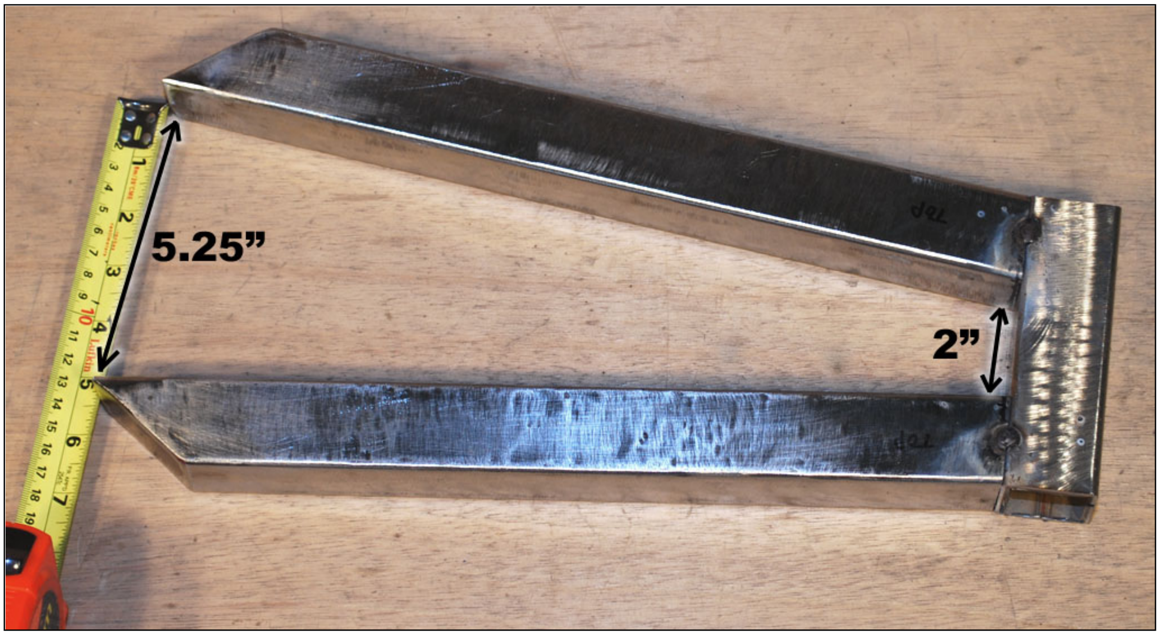

Figure 14 – Joining the two fork legs together

To complete the rear forks, they must be joined together by a small tube so that they are 5.25 inches apart at the open end, and 2 inches apart at the closed end as shown in Figure 14. The small tube that joins the fork legs will need to be 5 inches long in order to reach across the two tubes and the 2 inch distance. Tack weld the top of the new tube and fork legs while the three tubes are placed on a flat surface.

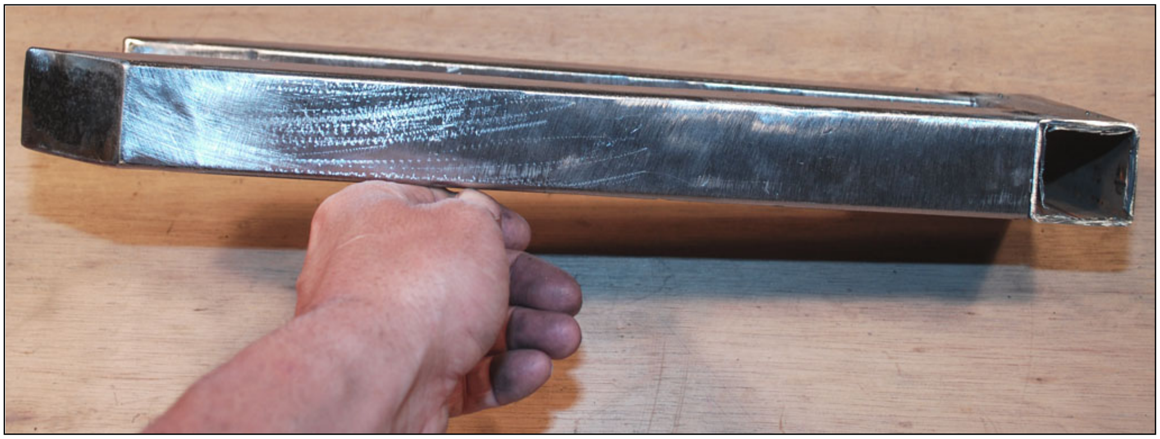

Figure 15 – Checking fork leg alignment

To check the parallel fork leg alignment, hold up the part as shown in Figure 15 to ensure that both legs are as parallel as possible. With only a few tack welds holding the parts together, it will be easy to tap them into alignment with a hammer, if necessary. Once alignment looks visually good, tack weld the bottom of the part to secure the legs to the small joining tube.

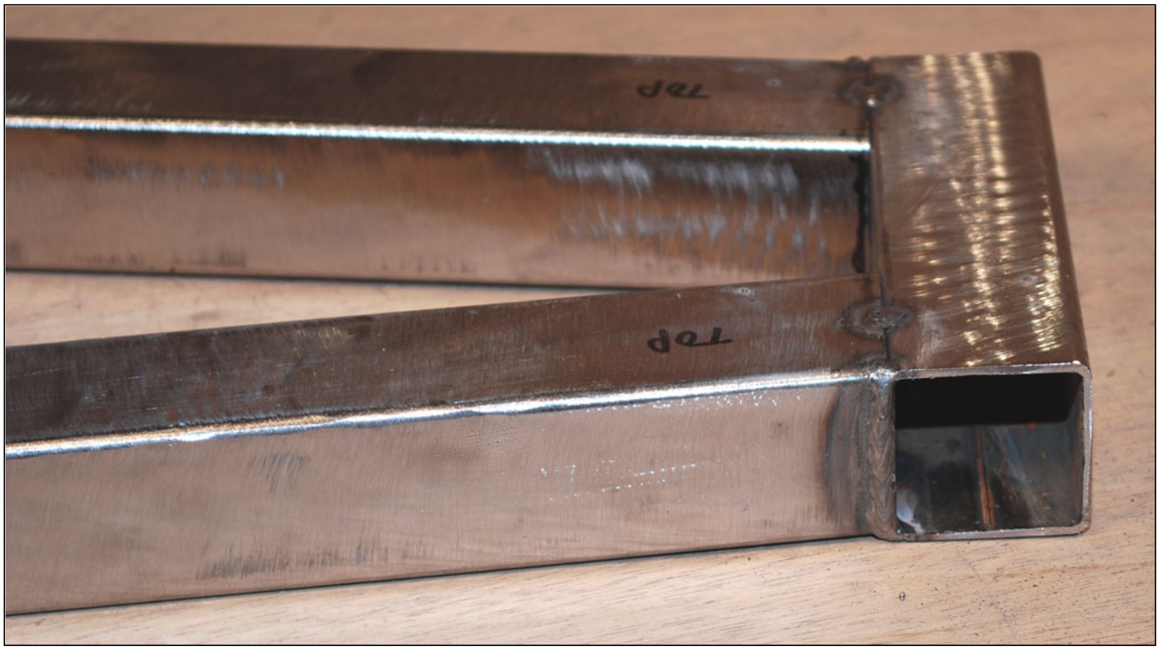

Figure 16 – Welding the sides of the joint first

To minimize the effects of distortion while welding square tubing, the order of welding becomes important. The first weld will be the one to introduce the most distortion as the weld area cools, so choose the side that will have the least amount of effect on the part. As shown in Figure 16, the outer edges are welded first, as the distortion will be minimal here, and it will not affect the most important alignment – the parallel alignment of the two fork legs. It's also a good idea to tack weld the straight edge or some bit of tubing between the fork legs while welding to further minimize and distortion.

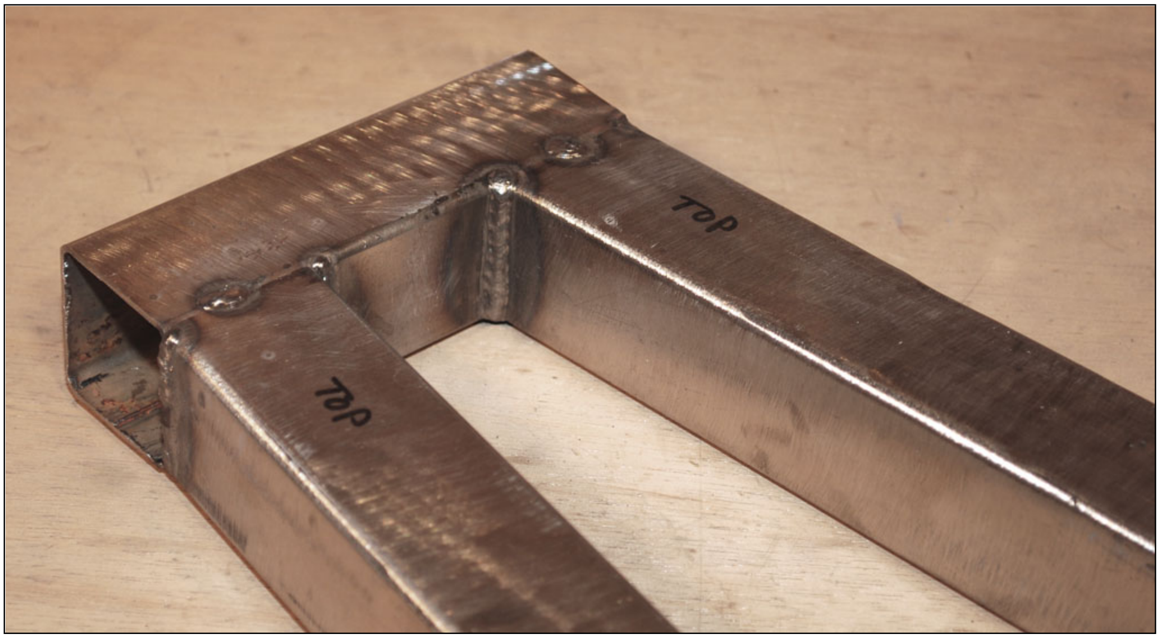

Figure 17 – Weld the inside corners next

The inside corners of the joint as shown in Figure 17 are to be welded next. Distortion will be minimal due to the other side of the joint having been welded earlier, but it still wouldn't hurt to have that bit of tubing tack welded between the legs to keep the axle spacing perfect. The reason I marked the top of the part is because the tubing seam will end up on the bottom side. Depending on your tubing, the seam may or may not be noticeable after painting.

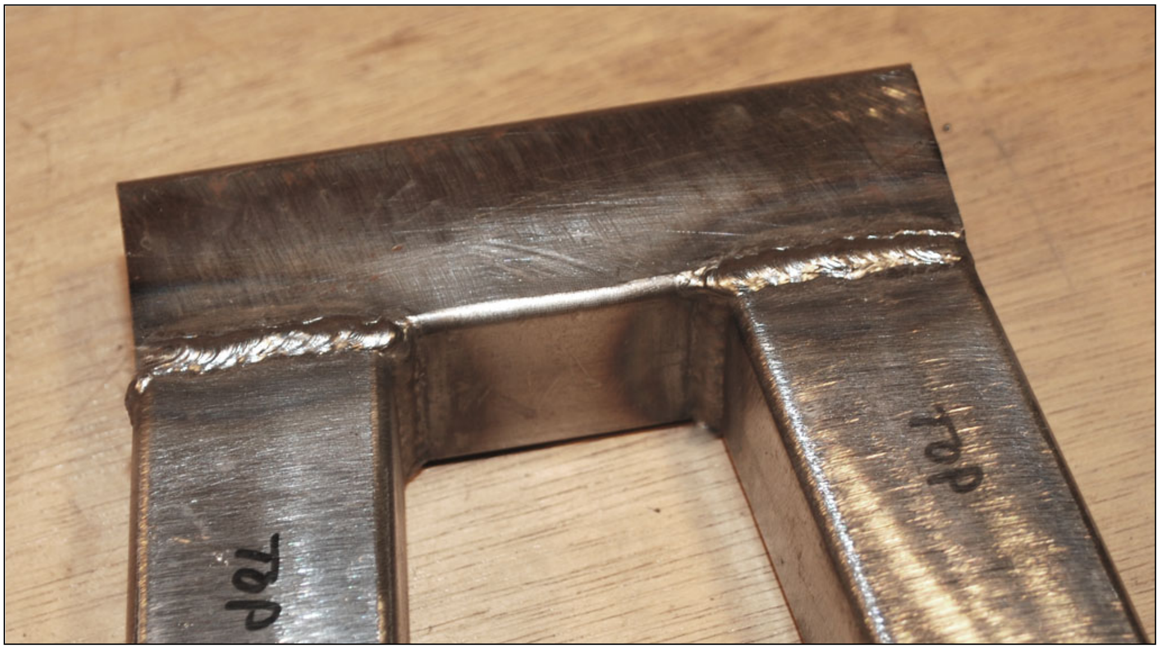

Figure 18 – Completing the top and bottom of the joints

The top and bottom of the joint can be completed next (Figure 18), but it is a good idea to weld both fork legs in the same order. Each time you weld, check the legs for parallel alignment and if one leg seems higher than the other, weld the opposite joint, imagining that the weld will "pull" apart somewhat in that direction. Heat distortion becomes very predictable after much practice.

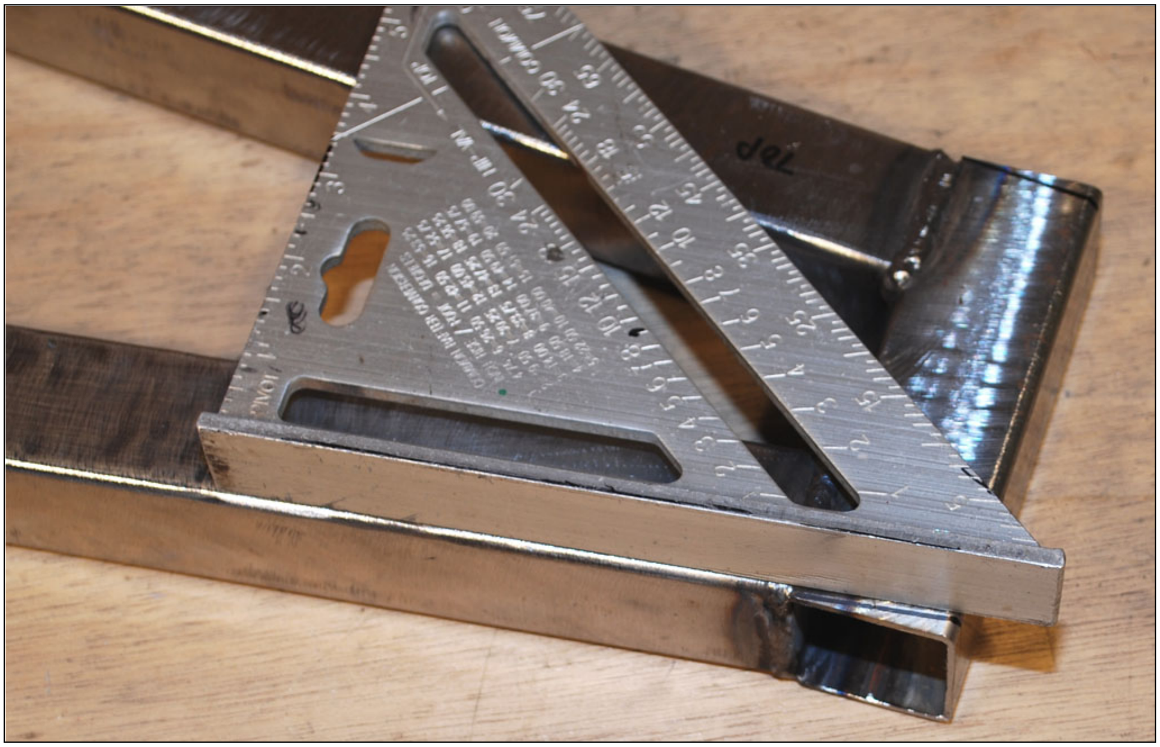

Figure 19 – Trimming the tube to match the angle

The step shown in Figure 19 is actually optional, but it does keep the angle of the fork legs running through the entire part. To trim the small tube, just place a straight edge along the fork leg, draw a line, then take away the small it of tubing using a zip disc or hack saw.

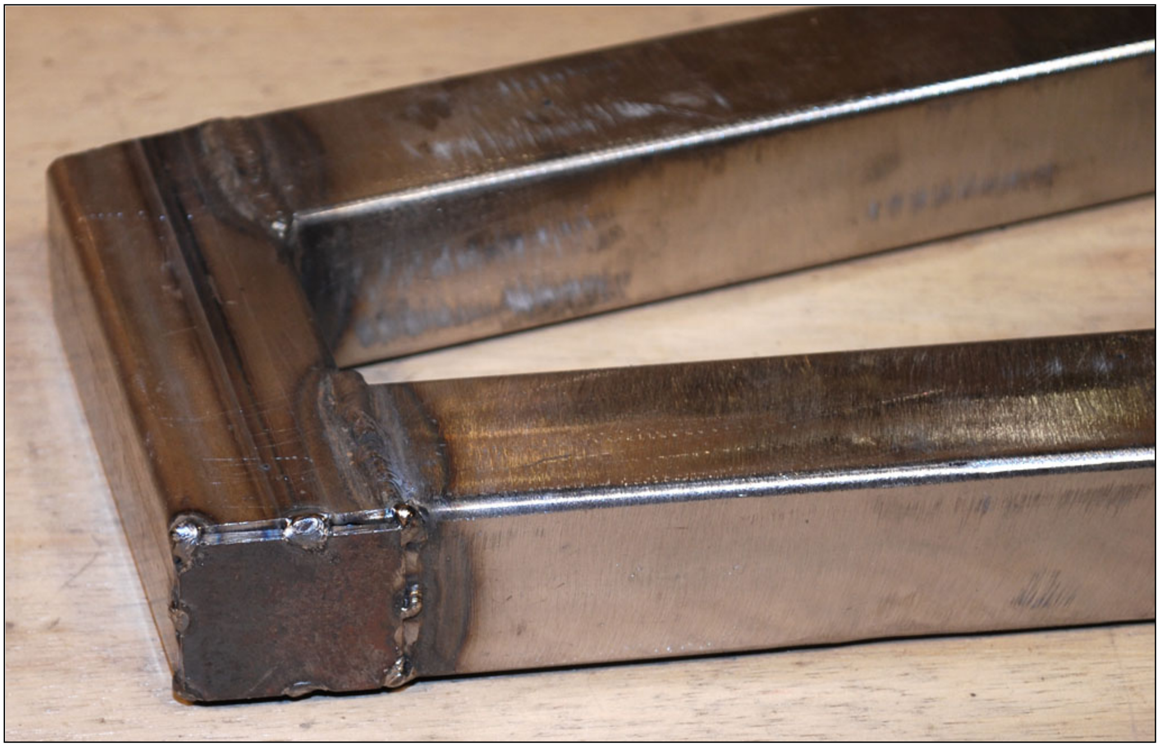

Figure 20 – Capping off the remaining holes

The small joining tube will also need to be capped, and those two bits that were cut from the 45 degree ends of the fork legs should be able to fit the holes once cut into squares. Figure 20 shows the beginning of the capping procedure, using a few corner tack welds to get started.

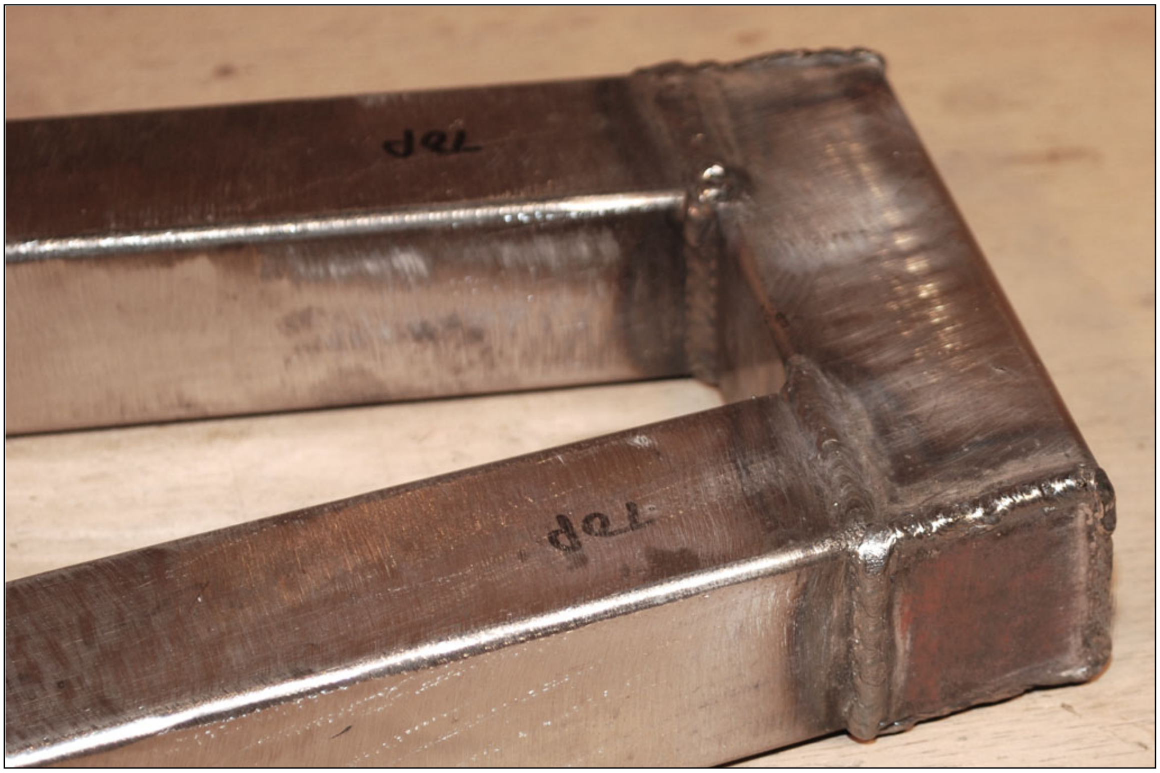

Figure 21 – Caps welded completely around

The process of cleaning up a tubing cap does take a bit of work, but when you compare the bulky welded area in Figure 21 to the completed work shown next in Figure 22, the results are certainly worth the effort.

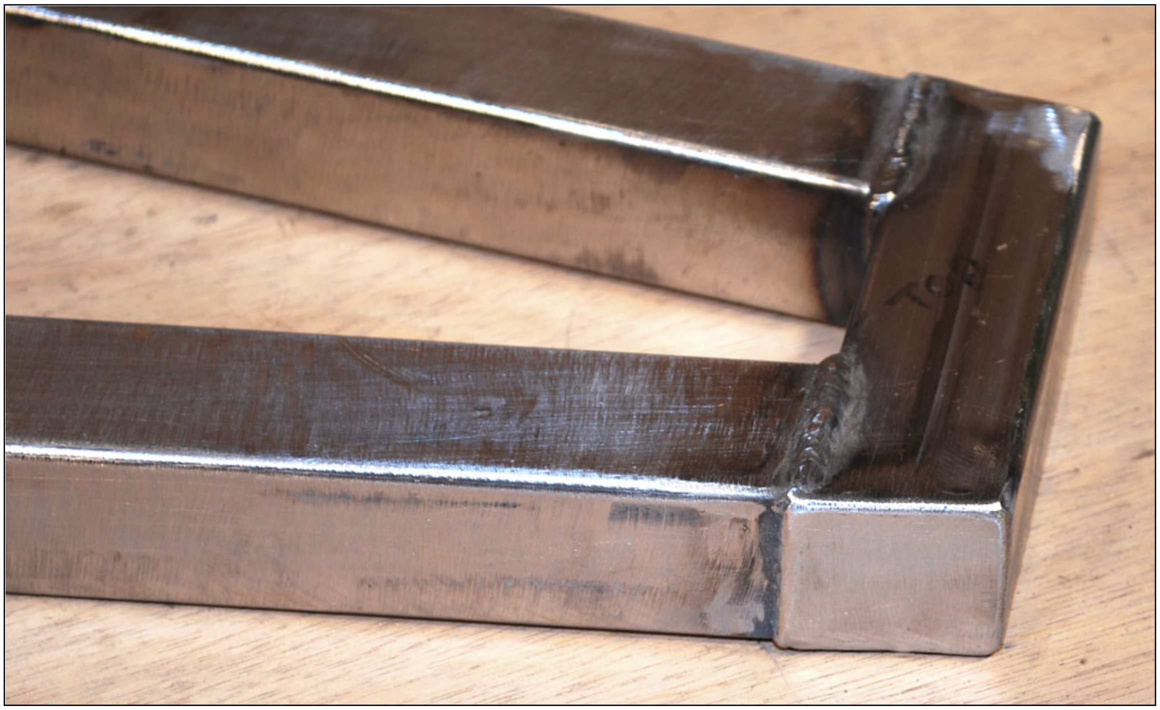

Figure 22 – Rear forks completed

The cleaned up tubing caps are shown in Figure 22 after a few hole fillings and reworking with the flap disc. This completes the rear forks, and next will be the rear dropouts that will hold the rear wheel to the fork legs.

Making Rear Dropouts

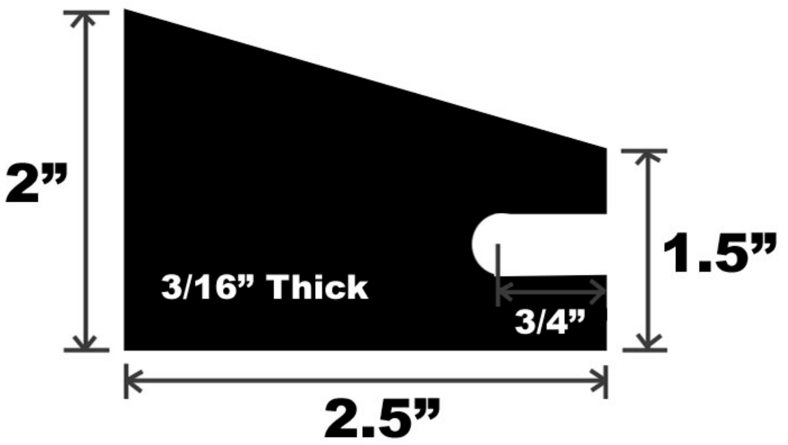

Diagram 1 – Rear dropout dimensions

The rear dropouts will place the rear axle approximately 2 inches underneath the rear of the fork legs so that there is room for the chain to reach the smallest rear chain ring without rubbing on the fork legs. Unlike a normal bicycle fork, where the axle is placed at the end of the fork legs, this would not work here due to the angle that the chain need to travel from the rear cluster to the idler under the seat. If you look way ahead to some of the completed Warrior photos, you can see how the chain leaves the rear freehub cluster. These dropouts are just pieces of 3/16 inch thick flatbar or sheet metal cut to the dimensions shown in Diagram 1.

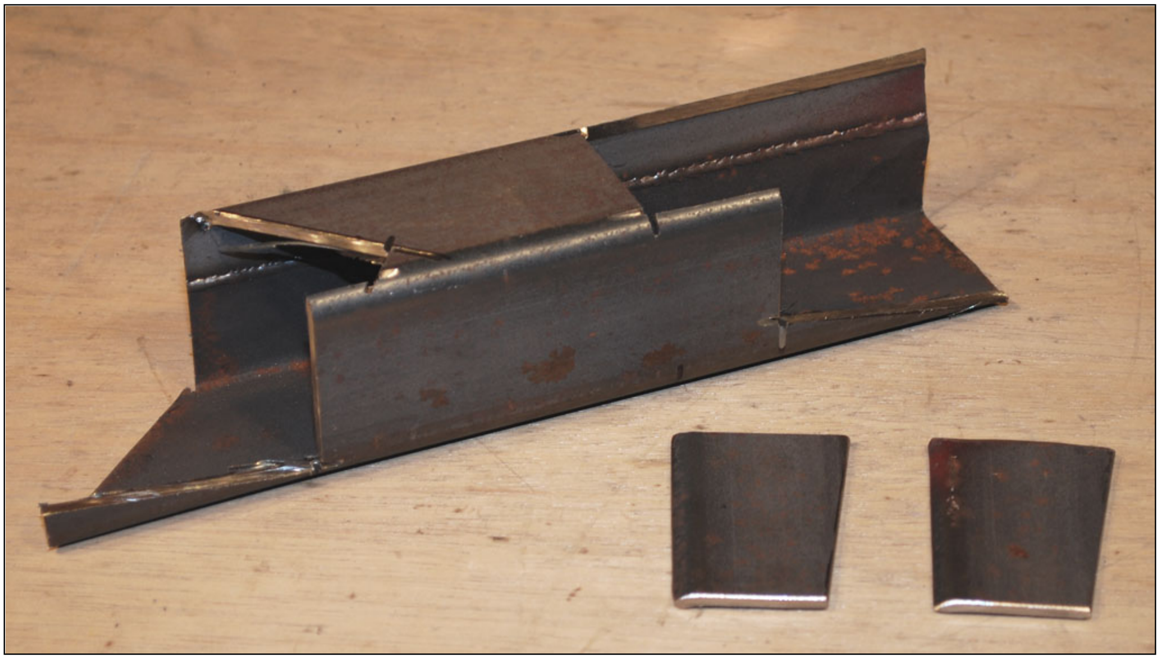

Figure 23 – Cutting out the rear dropouts

Since I have a large collection of scrap tubing bits, I decided to recycle some large 2 inch square tubing (Figure 23) that just happened to have the correct (or close enough) thickness for the rear dropouts. A little less than 3/16 inch thick sheet will be fine, but 1/16 inch thick would be getting a bit on the flimsy side, especially if you like to lock up your rear wheel and skid around corners. If you are really concerned about weight, choose the thicker plate, and just drill a few ¾ inch holes in the completed dropouts.

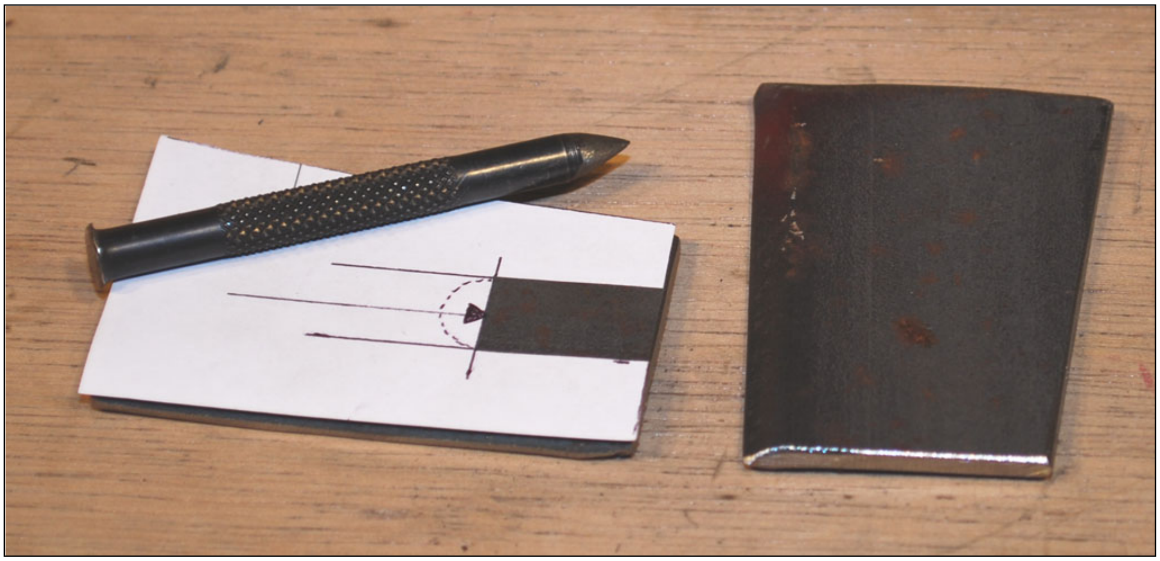

Figure 24 – Using a template to punch the axle holes

As per Diagram 1, there needs to be a slot cut to a depth of ¾ inches to allow your rear axle to bolt onto the dropouts. There are several diameters of rear axles, so you need to choose a final slot diameter that will match your rear wheel. To make the slot with a rounded top, carefully measure or use a template as shown in Figure 24 to find the exact point to punch so you can begin drilling. What matters the most is that both dropout slots are in the same place.

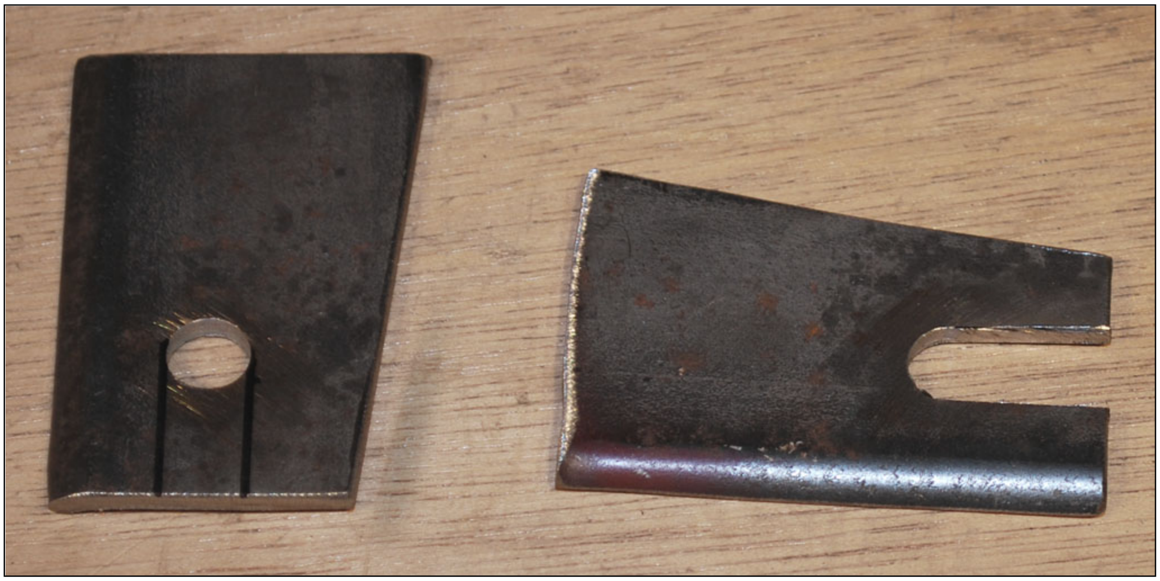

Figure 25 – Making the dropout slots

To drill an accurate hole, I punch the center, then work my way up the drill bit set, starting with the 1/8 inch bit first. A step drill will do the same thing if you have one available. Figure 25 shows the axle holes drilled and the method used to create the rest of the slot. Just draw lines from the edge of the holes to the bottom of the dropout and then cut them with a zip disc or hacksaw. After you have the slots cut, place both dropouts together and grind them to be exactly the same if they are not.

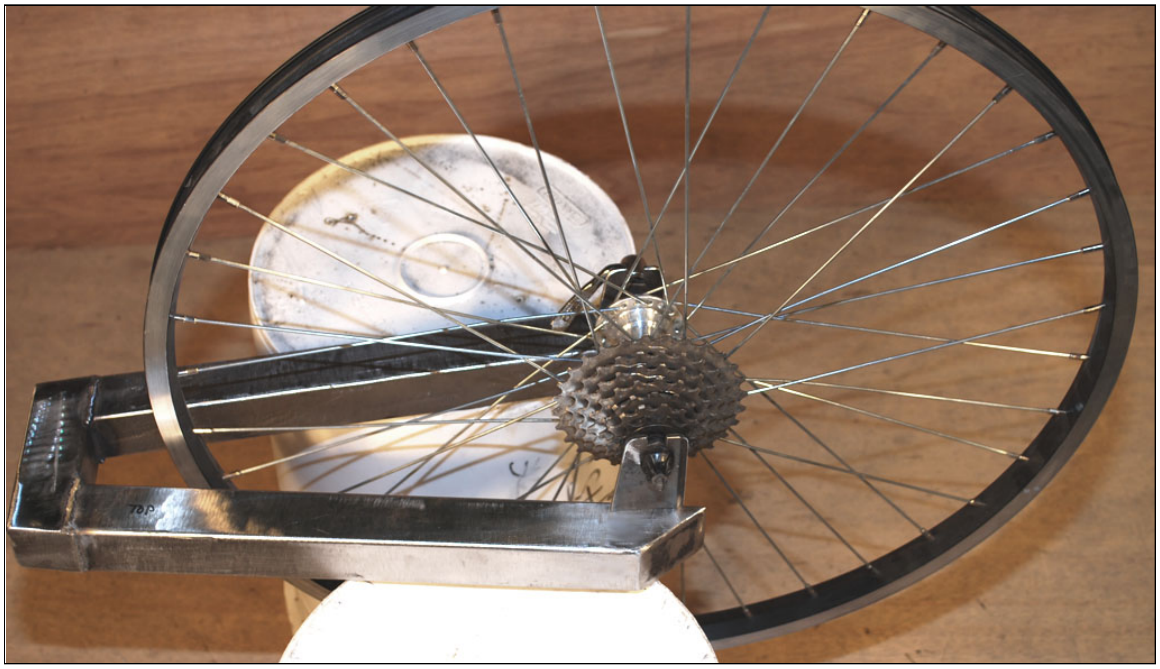

Figure 26 – Using a rear wheel as an alignment guide

The rear dropouts are placed about ½ inch from the end of the fork legs as shown in figures 26 and 27. By using a rear wheel as a guide, you create the perfect spacing for the dropouts, and can check the alignment by looking at the rim between the fork legs. Don’t use your best rim when welding the parts to the fork legs, but do use a straight one!

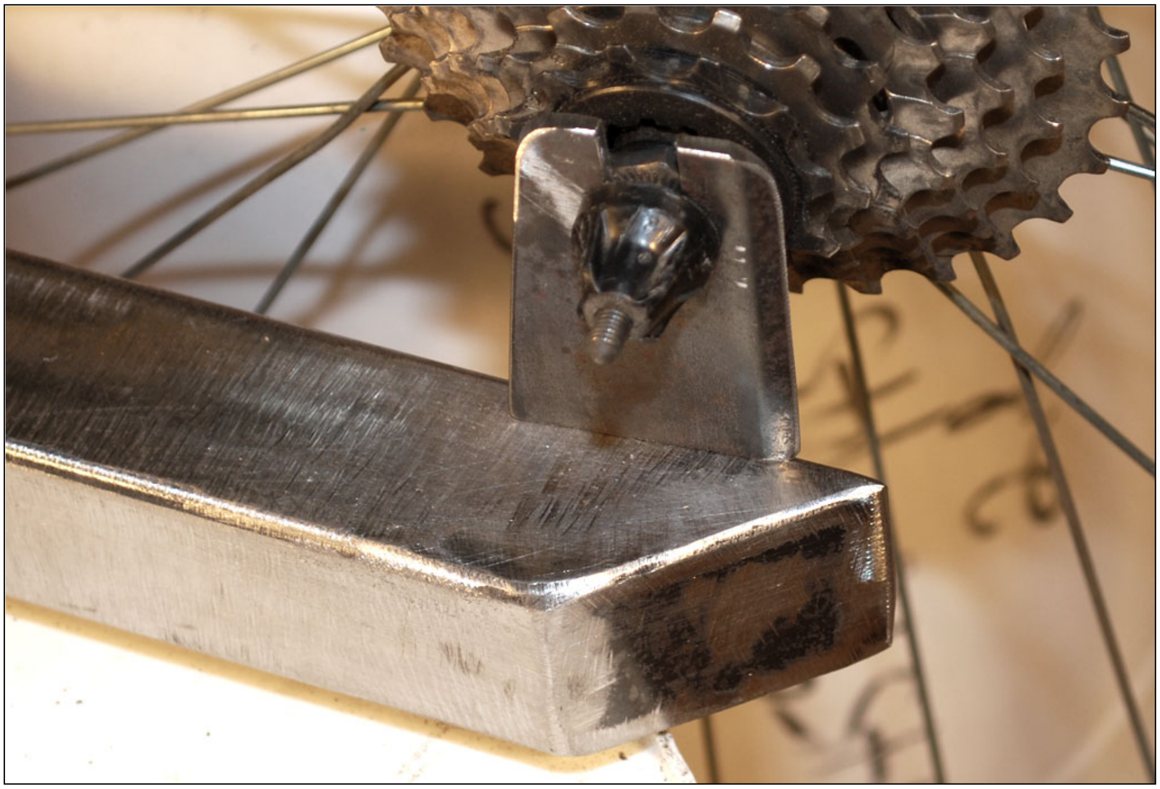

Figure 27 – Positioning the dropouts to be welded

Because the fork legs are at an angle and the dropouts are parallel with the hub, the rear end of the dropout will be close to the inside edge of the fork leg than the front end as shown in Figure 27. What matters is that the rear wheel is perfectly centered in between the fork legs, which is why it is needed as a guide.

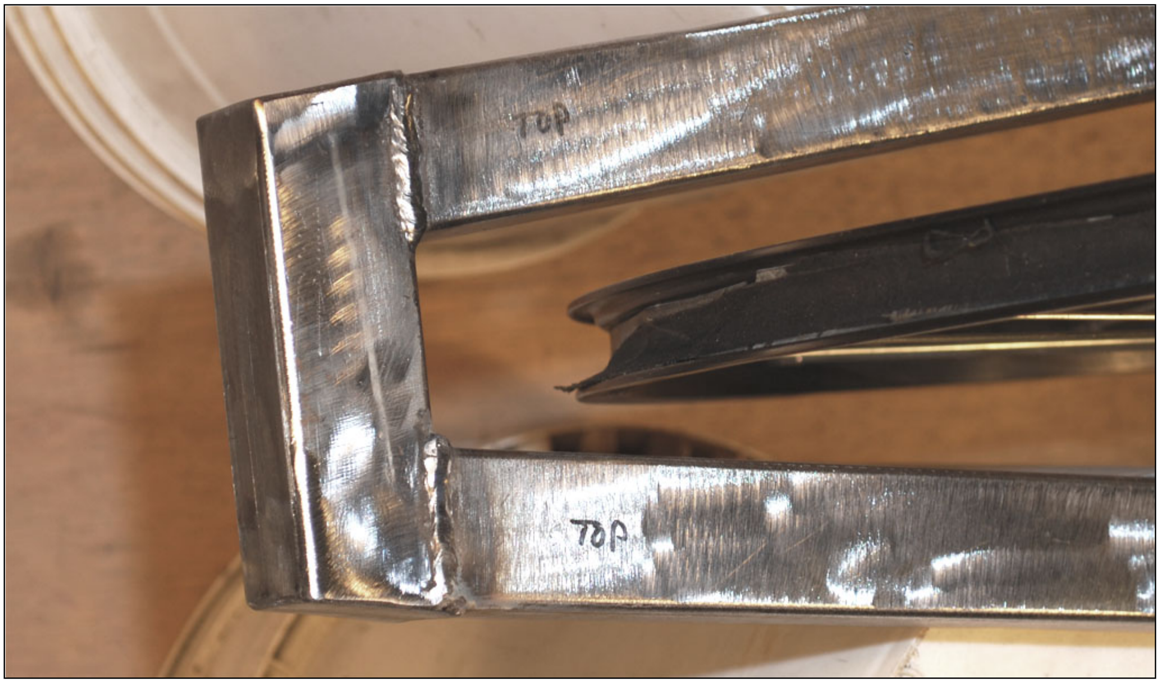

Figure 28 – Checking rear wheel and fork leg alignment

Make one small tack weld on one corner of one of the rear dropouts and then ensure that the rim is perfectly aligned between the two fork legs as shown in Figure 28. Give the wheel a spin to ensure that it does not have a wobble as well. Once the wheel seems to be perfectly aligned, make another small tack weld on the other dropout to secure the axle position.

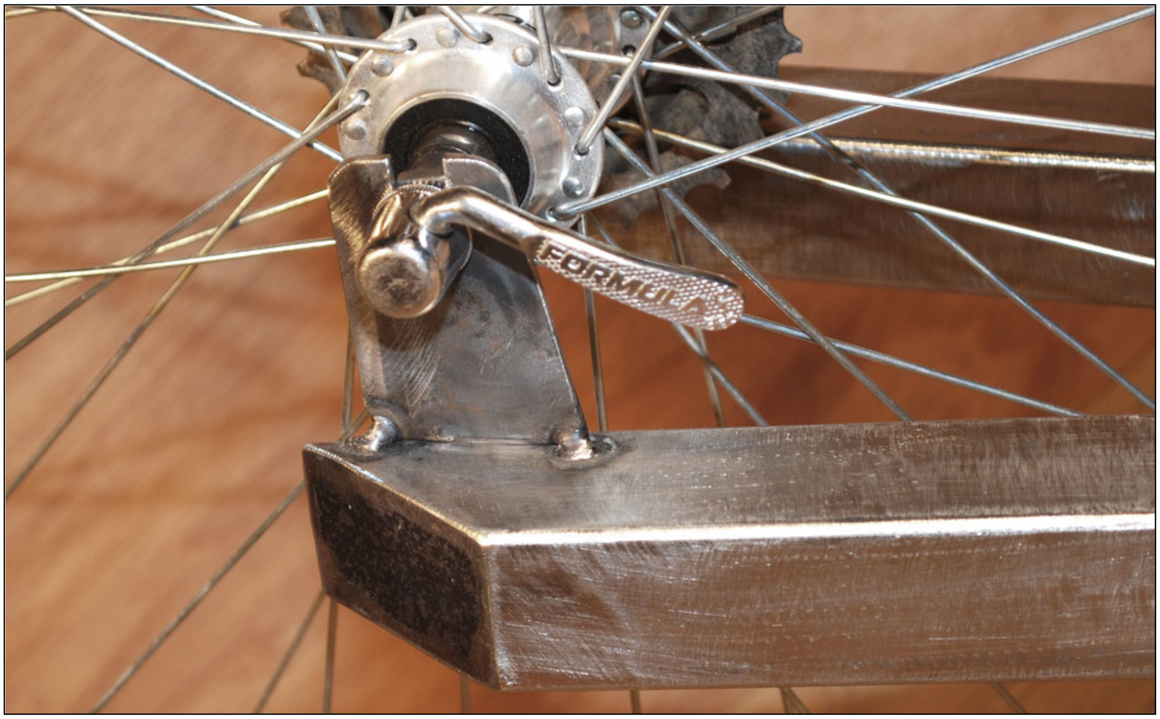

Figure 29 – Securing the dropouts for welding

With a tack weld on each corner of the dropouts as shown in Figure 29, you should be able to pick up the forks and visually inspect the wheel alignment from all angles. The wheel should be perfectly centered, as well as form a 90 degree angle with the small joining tube.

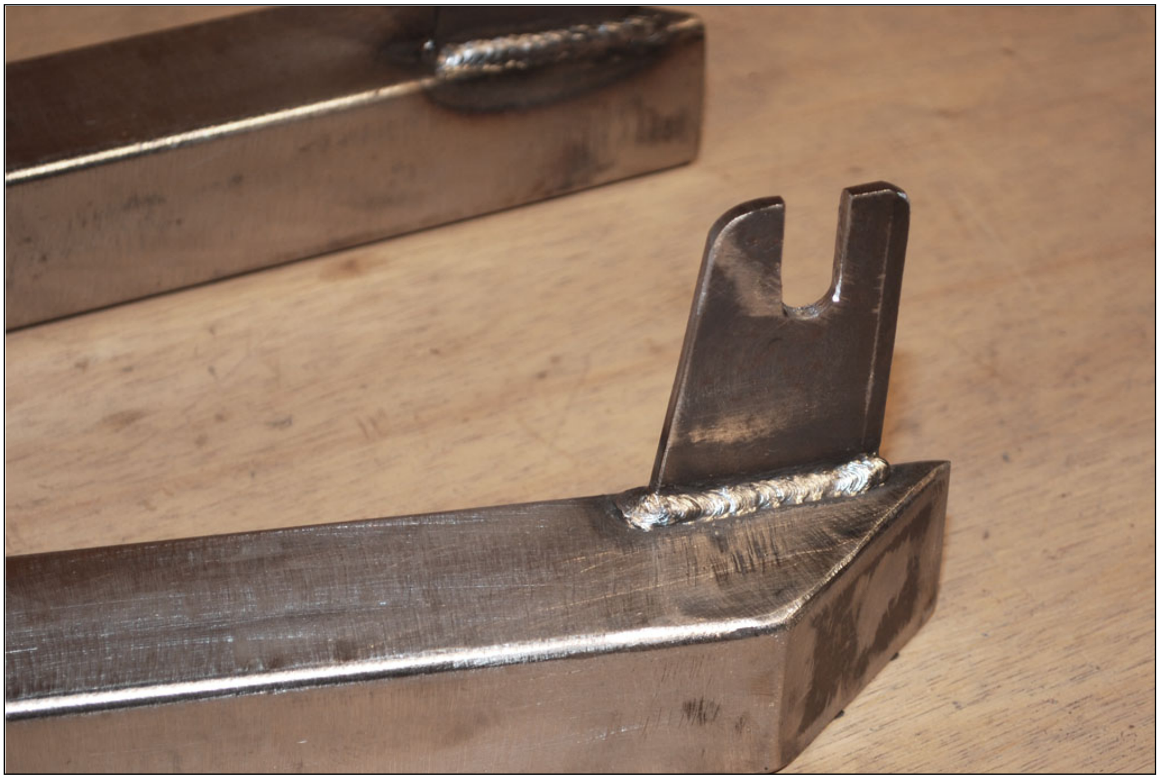

Figure 30 – Welding the dropouts to the fork legs

It's best to completely weld the dropouts to the fork legs while the rear wheel is still installed as it will keep distortion to a minimum. If you only have a single good wheel, a threaded rod with bolts will also hold the dropouts secure while welding. As shown in Figure 30, start with the outside of the joints.

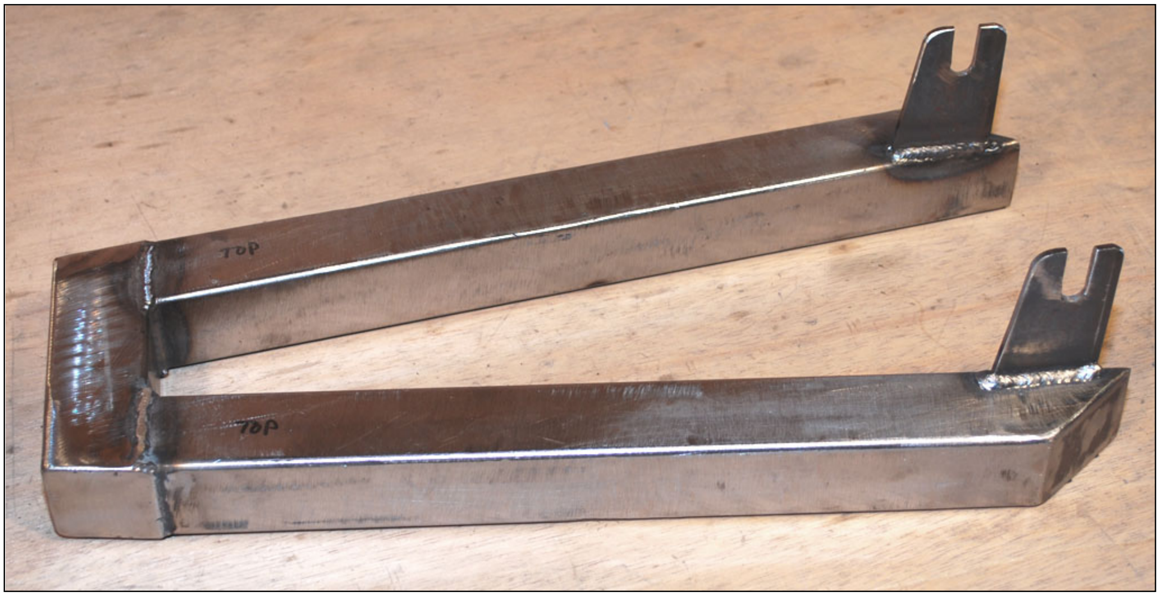

Figure 31 – Rear fork assembly completed

Making the Rear Seat Tube

The inside of the joints can be safely welded as shown in Figure 31 once the outer joints have been completed. You will not need a wheel holding the dropouts in place while completing the inside of the joints, as the outer welds will hold the dropouts secure.

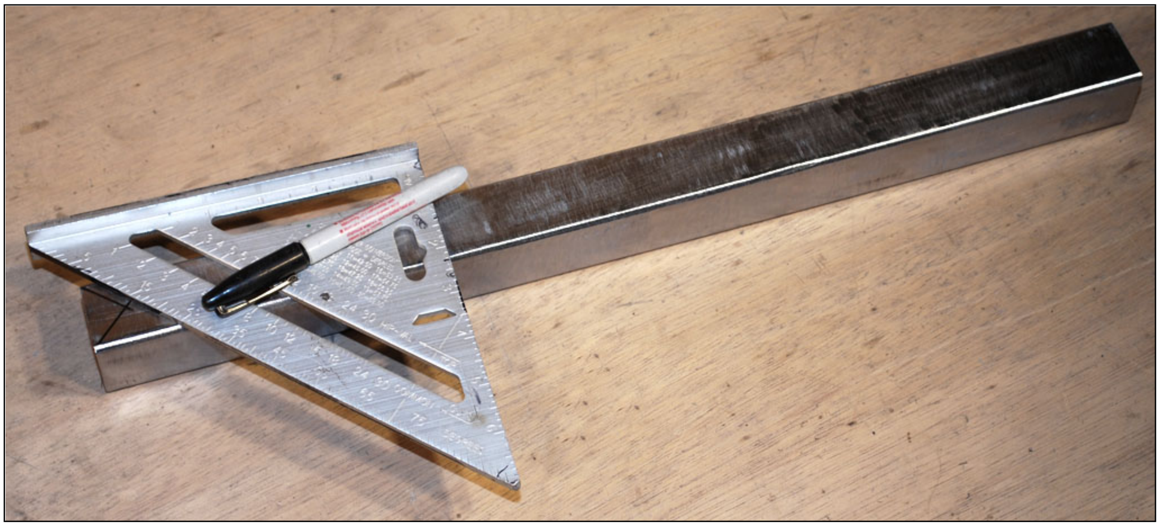

Figure 32 – Cutting the rear seat tube

The rear seat tube joins the rear forks to the frame and is where your back will be when you are sitting in the seat. This is another length of 1.5 inch square tubing initially cut to a length of 20 inches. Also shown in Figure 32 is a 45 degree triangular cut that will be made at one end of the tube in order to meet up with the edge of the rear forks, which will be shown later.

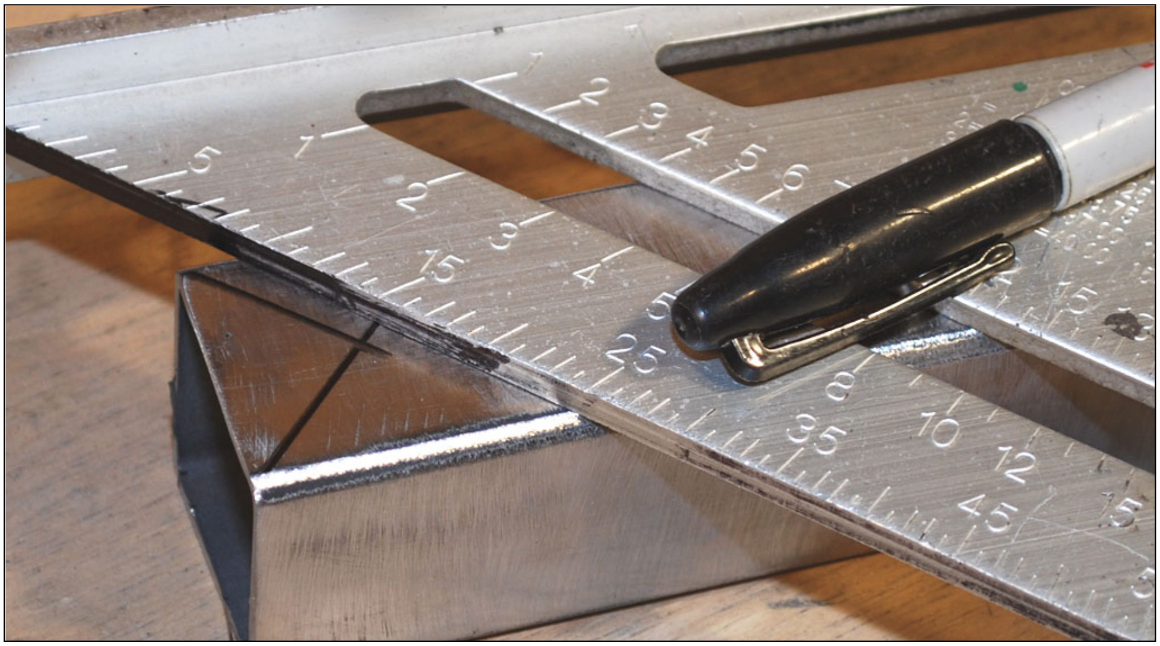

Figure 33 – Marking the triangle to be cut away

The triangle cut is marked by using a 45 degree square to draw lines from each corner until they cross as shown in Figure 33. This is done on both sides of the tube.

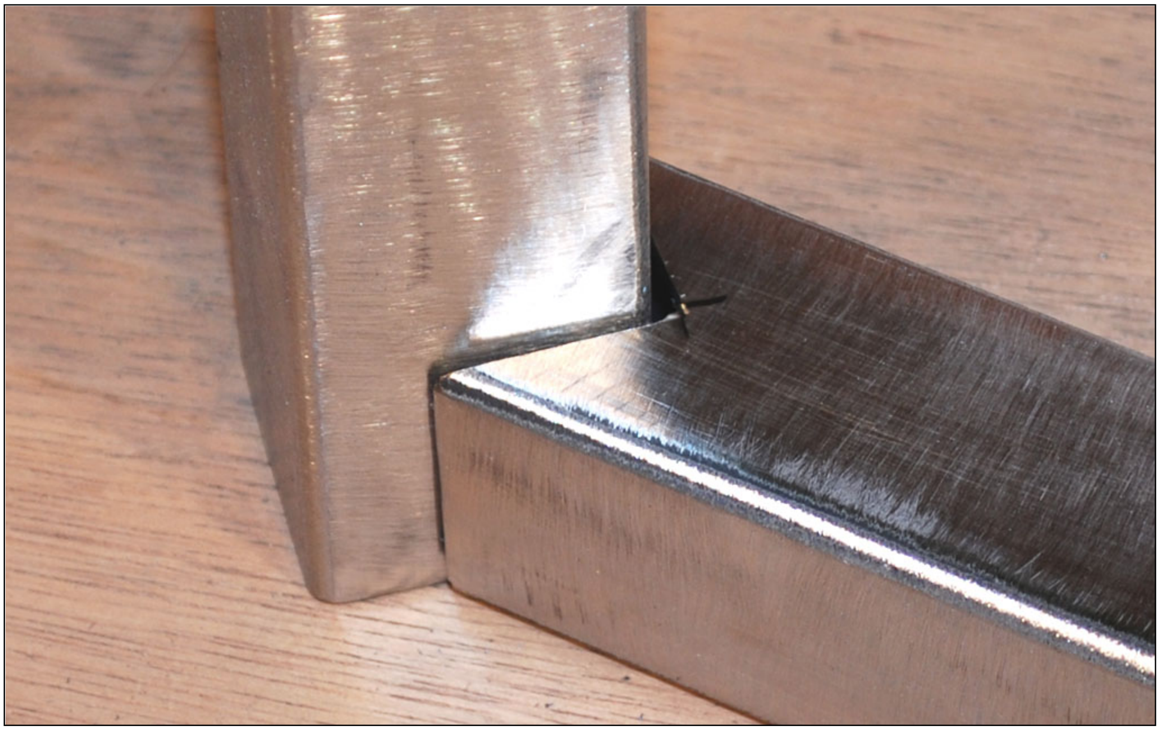

Figure 34 – Test fitting the tubing joint

Once cut away, the end of the seat tube should fit snugly against any square tube places into the joint at 45 degrees as shown in Figure 34. If you rest a tube across the joint, holding it up like a "T", it is easy to check to see of the triangle cutout is the same on both sides.

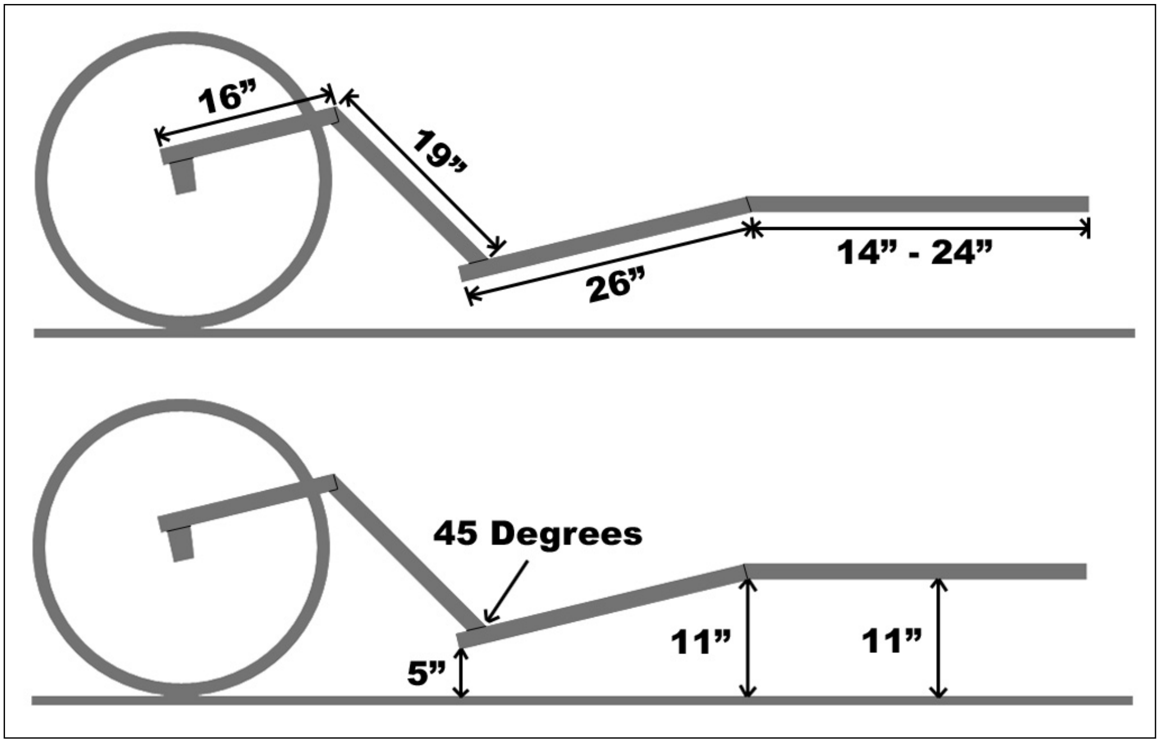

Diagram 2 – Frame angles and ground clearances

The Warrior frame will be built from the ground up (literally), so all of the key angles and clearances are easy to get right without any guesswork. If you have plans to make any radical frame changes, then this is the time to work them out. Looking at Diagram 2, you can see that the key angles and lengths will affect ground clearances and seat angle. Approximately 11 inches is about as low as your front boom can be without having your heels scrub the ground, and 5 inches is about as low as your frame can be without having ground clearance issues during "normal" urban riding. If you have size 12 or larger feet, and love toe clip pedals, then you might consider a slightly higher boom to keep your heels from scrubbing the ground. For most riders using regular pedals, this height will be good.

Also shown in Diagram 2 is the range in front boom length that varies from 14 inches to 24 inches. If you do not know what type of seat you plan to install, and have no clue who the tallest rider will be, then go for the longer measurement at first and then trim the boom after the seat and cranks are installed. My final front boom was trimmed to 15 inches, and I am 5 foot – 8 inches tall and use a very thinly padded seat.

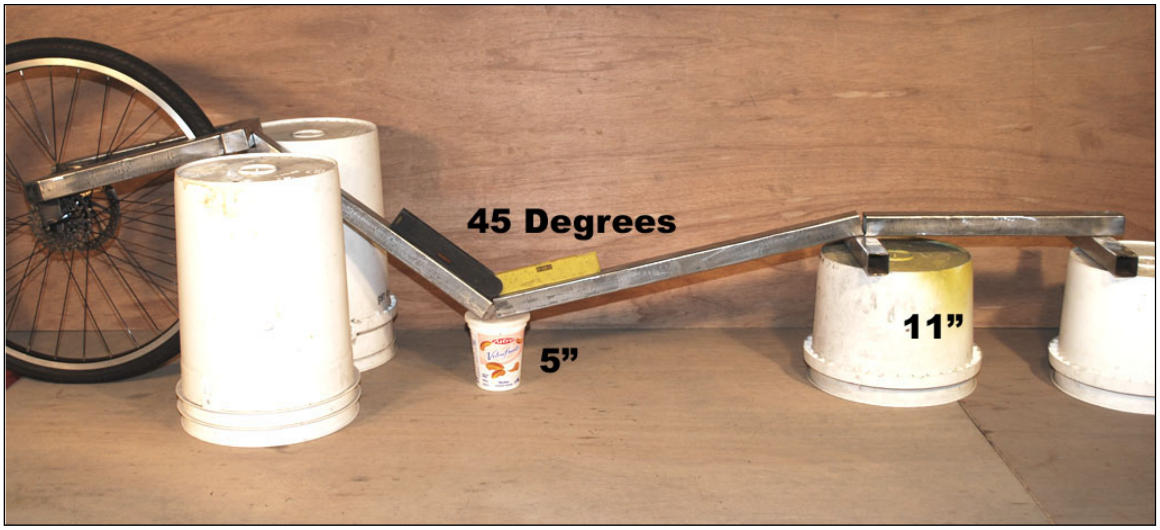

Figure 35 – Setting up the main frame tubing for cutting

Figure 35 demonstrates what I meant by building the Warrior from the ground up. By propping up the rear forks and the other three frame tubes to the correct ground height, you can easily derive the end cuts by using the other tubing as a guide. Also shown in Figure 35 is the seat angle of 45 degrees made between the rear seat tube and the center boom tube. Use buckets, bricks, boards, or whatever you have around the shop to get the tubing set up at the correct ground clearances. You also need to ensure that your rear tire is fully inflated at this point.

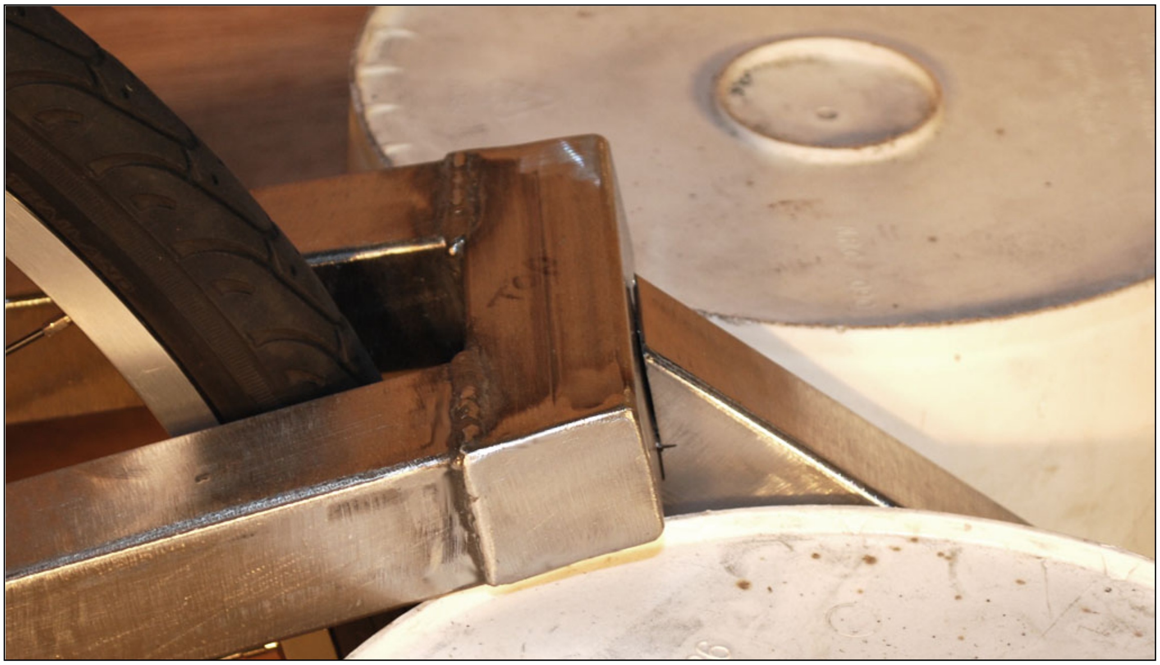

Figure 36 – Fitting the seat tube into the rear fork

The seat tube fits up against the rear fork assembly as shown in Figure 36, with the triangular cut centered on the small joining tube. When you are propping up the frame tubes for reference, don't worry about deadly accuracy, just get the ground clearances and seat angle as close as you can. Alignment and gap filling will be taken care of during the welding process.

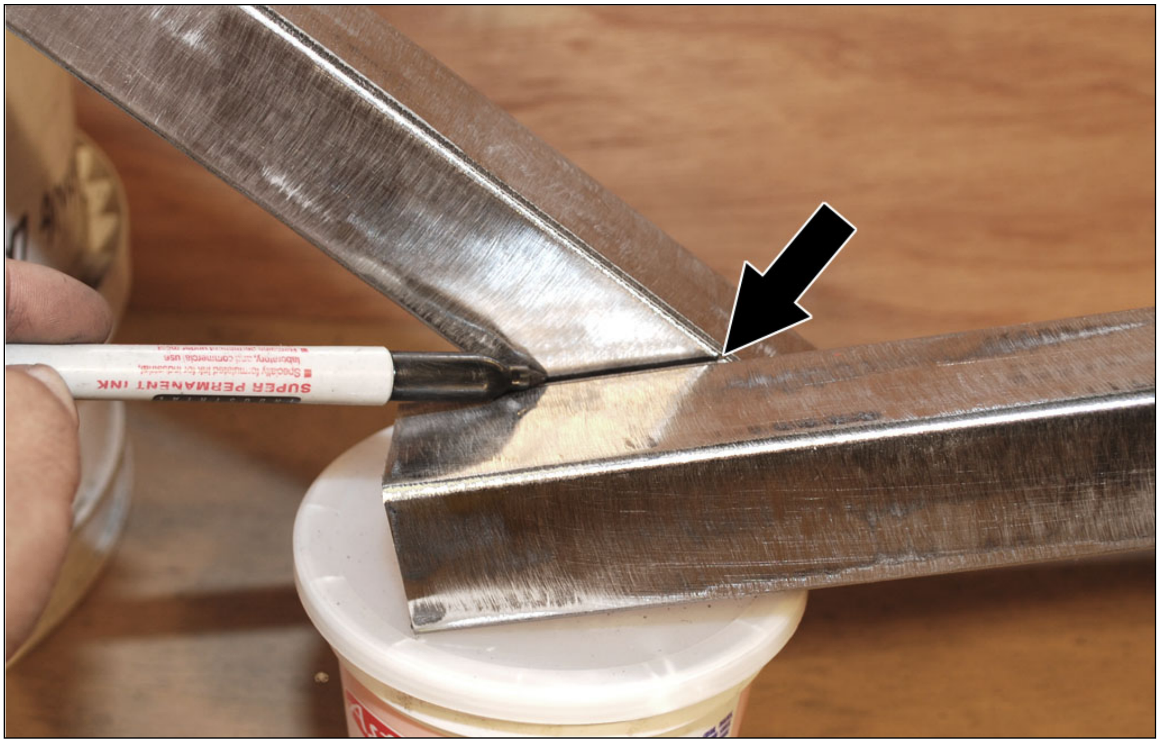

Figure 37 – Marking the seat tube cut at 19 inches

The seat tube will be cut at approximately 19 inches from the top as shown in Figure 37. What is most important is that the seat angle is 45 degrees as formed between the seat tube and the center boom (arrow in Figure 37). To mark the boom for cutting, just allow the seat tube to rest on the same surface that is holding the center boom off the ground at 5 inches, and then draw a line across the top of the center boom as shown in Figure 37.

Also notice that there is 1 inch of tubing sticking out past the seat tube, which is just there to make welding easier. So to sum this step up, ensure that both tubes are resting on a surface that is 5 inches from the ground and that the seat angle is 45 degrees. When you draw the line, the resulting seat tube will be approximately 19 inches in length. If you have made a radical change such as the use of a 24 inch or smaller rear wheel, the length of the seat tube will vary accordingly.

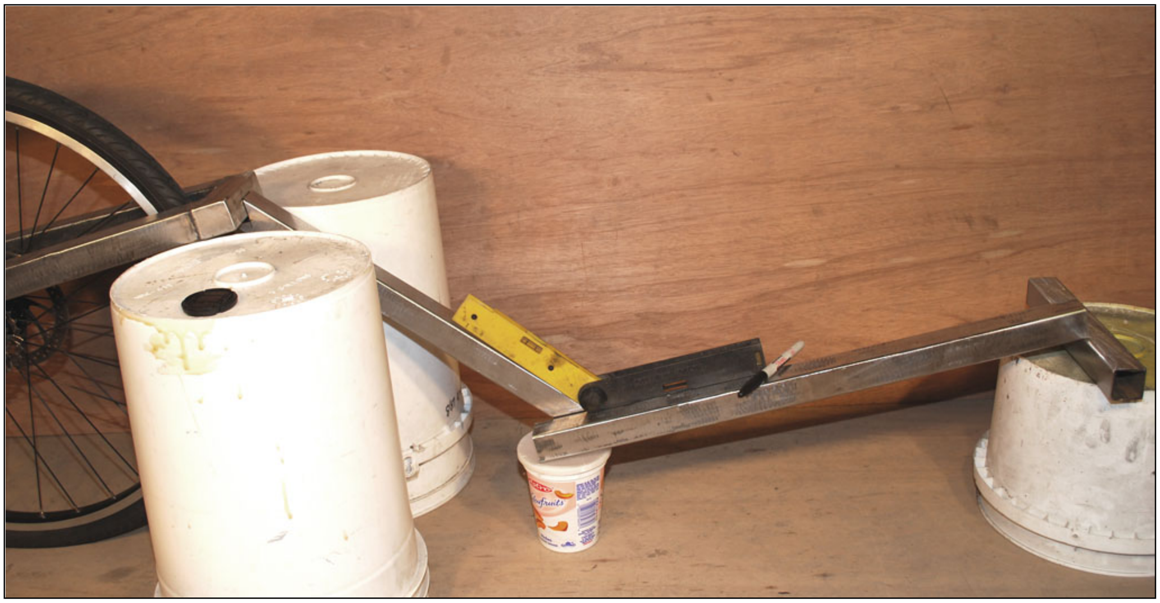

Figure 38 – Ready to cut the seat tube

Figure 38 is just another shot of the rear seat tube and center boom set up and ready for cutting after marking the line.

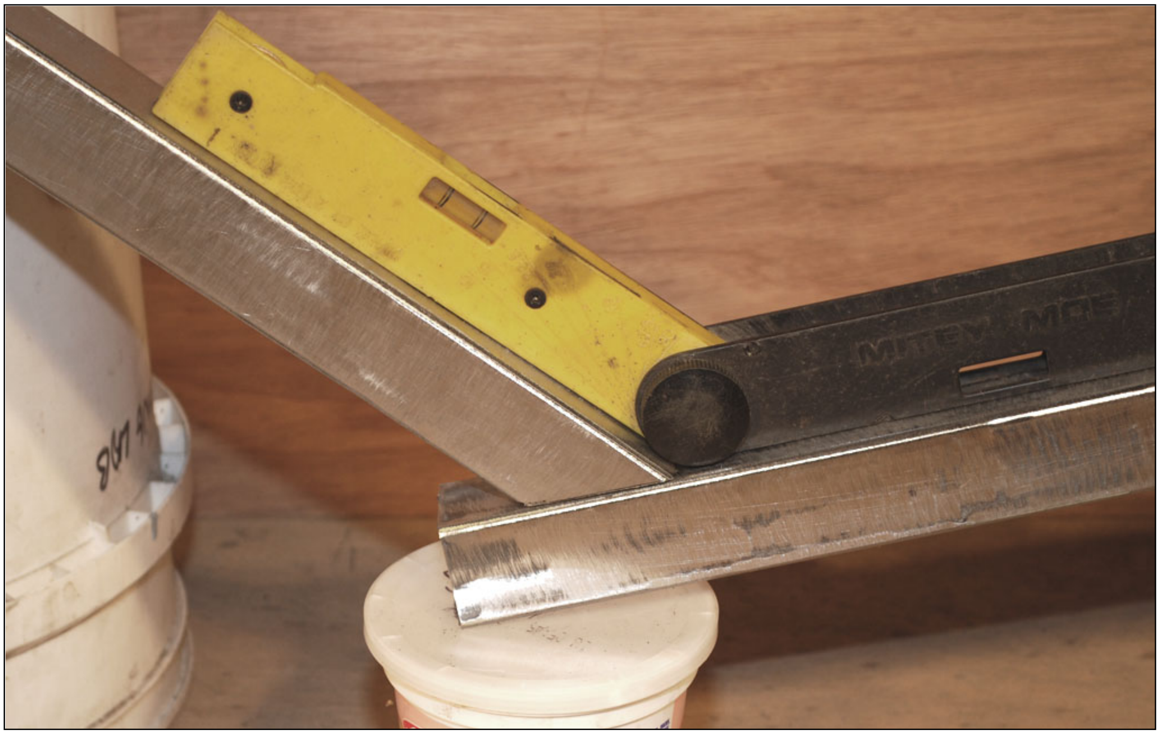

Figure 39 – Testing the angles after cutting

Front Boom

After cutting the seat tube angle, place the frame back into position and then recheck the angles and clearances. Figure 39 shows the freshly cut rear seat tube now resting on top of the center boom about 1 inch from the end. The angle is still exactly 45 degrees for the seat.

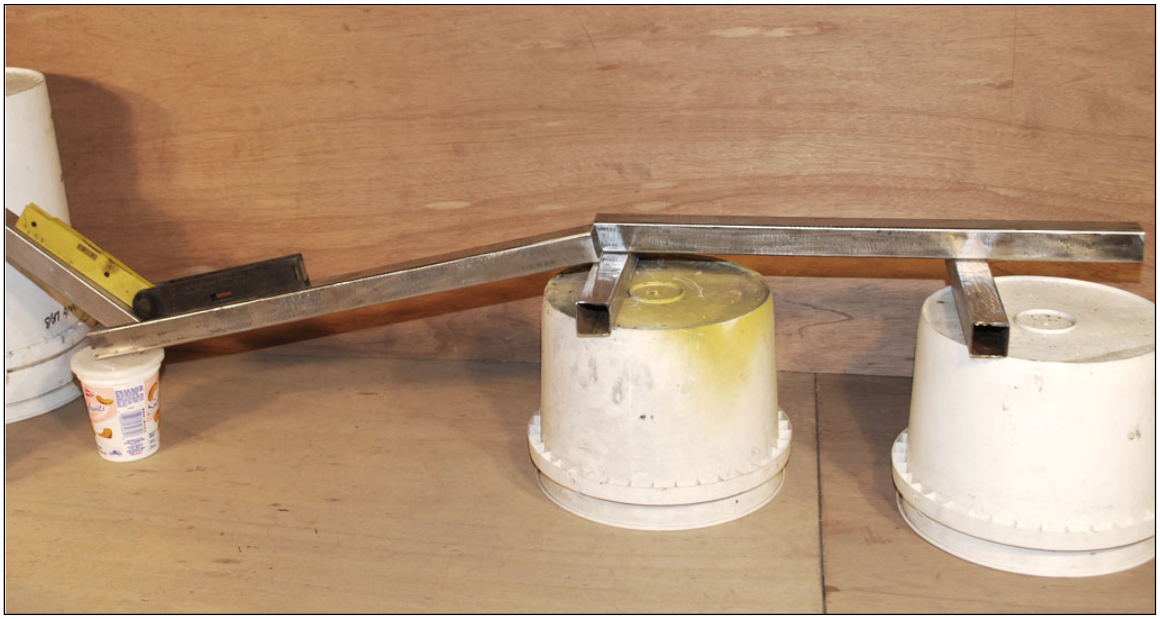

Figure 40 – Setting up the front boom for cutting

The front boom is set up the same way for cutting, using the end of the center boom as a trimming guide. Make sure the end of the center boom is 11 inches from the ground, then slide the front boom alongside the center boom so that you can draw a line to make the angled cut.

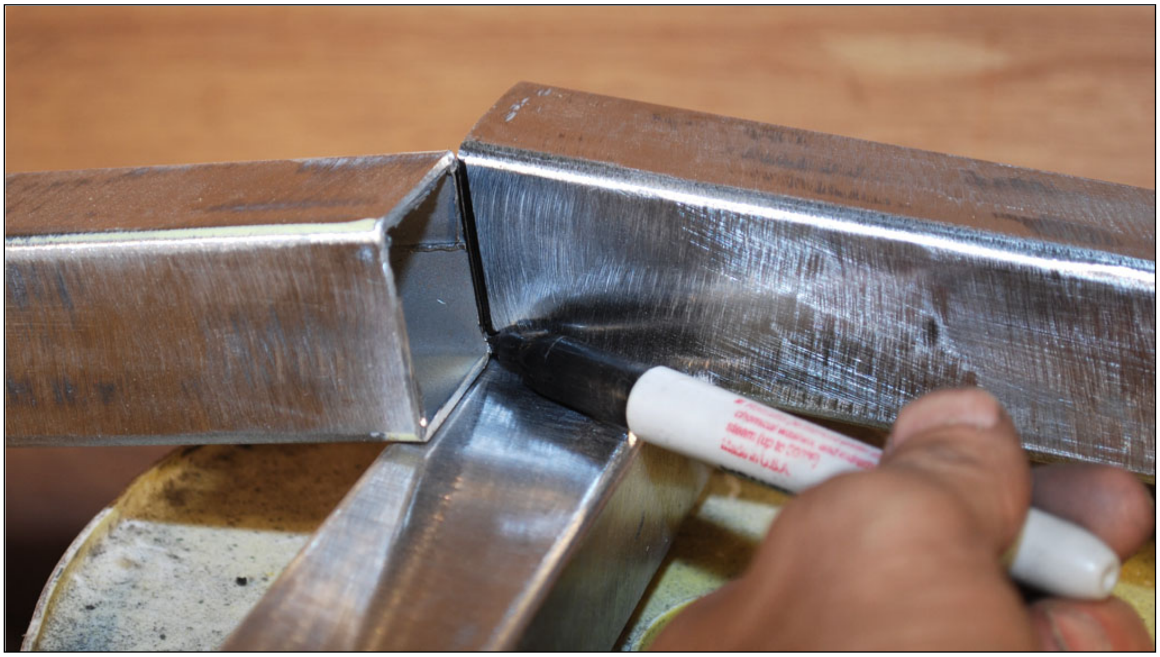

Figure 41 – Marking the front boom for cutting

The front boom is marked for cutting as shown in Figure 41, using the end of the center boom as a guide. This method of cutting angles ensures a perfect joint every time, without messing around with fractional angles. The only frame angle I even know is the seat angle, and that was chosen for comfort and aerodynamics.

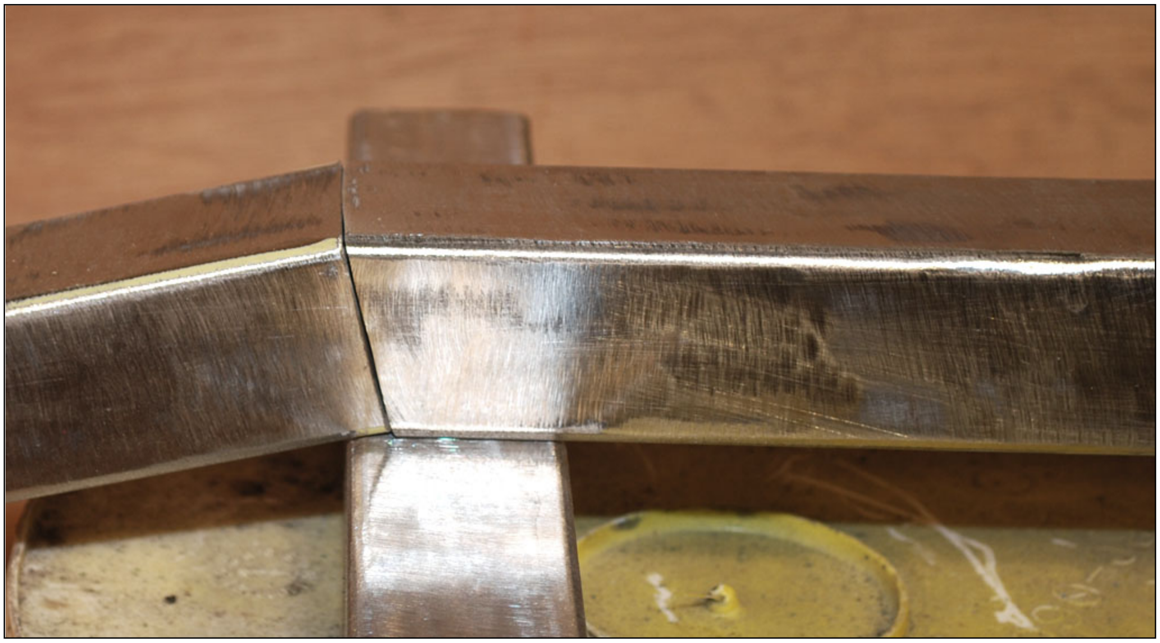

Figure 42 – Test fitting the front boom

The front boom is shown up against the center boom after cutting the angle marked in the previous step… a perfect fit again. If for some reason, your cuts were not perfect, just use a flat file or flap disc to clean up the end of the boom until there is almost no gap in the joint.

Weld the Tubes in Order

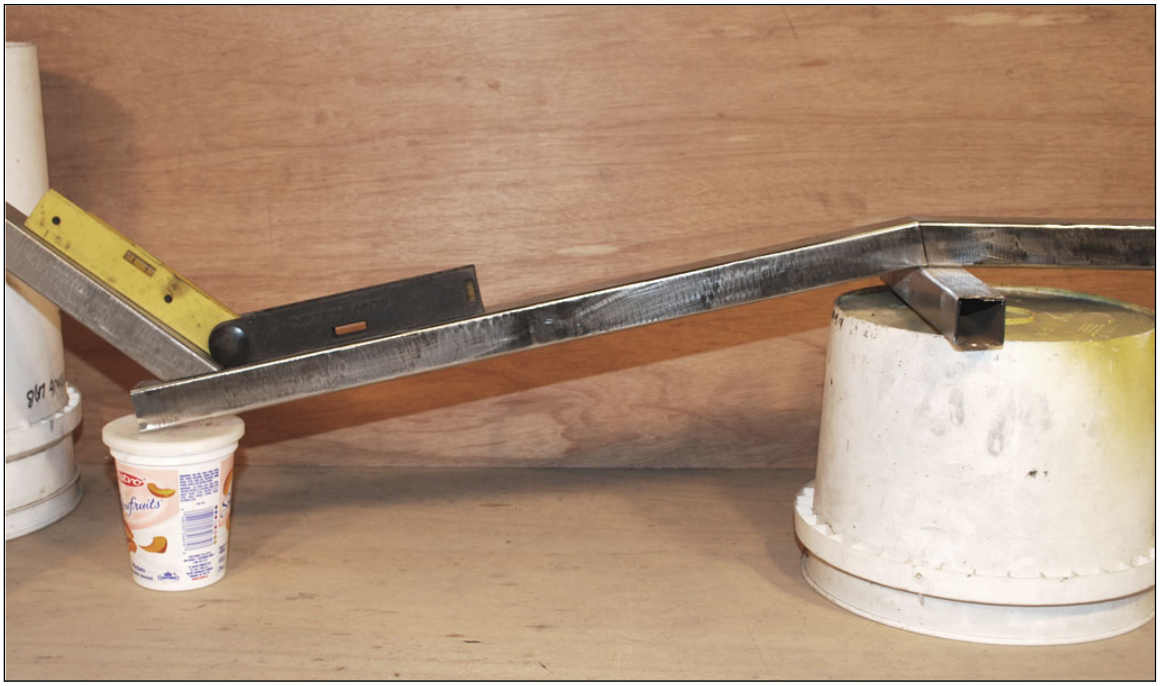

Figure 43 – One last angle and clearance check

Now that you have your three main frame tubes cut, set them all up one more time and double check your ground clearances and seat angle (Figure 43). Most likely, everything will be perfect, since it was built from the ground up, but it never hurts to check your work before the sparks begin to fly.

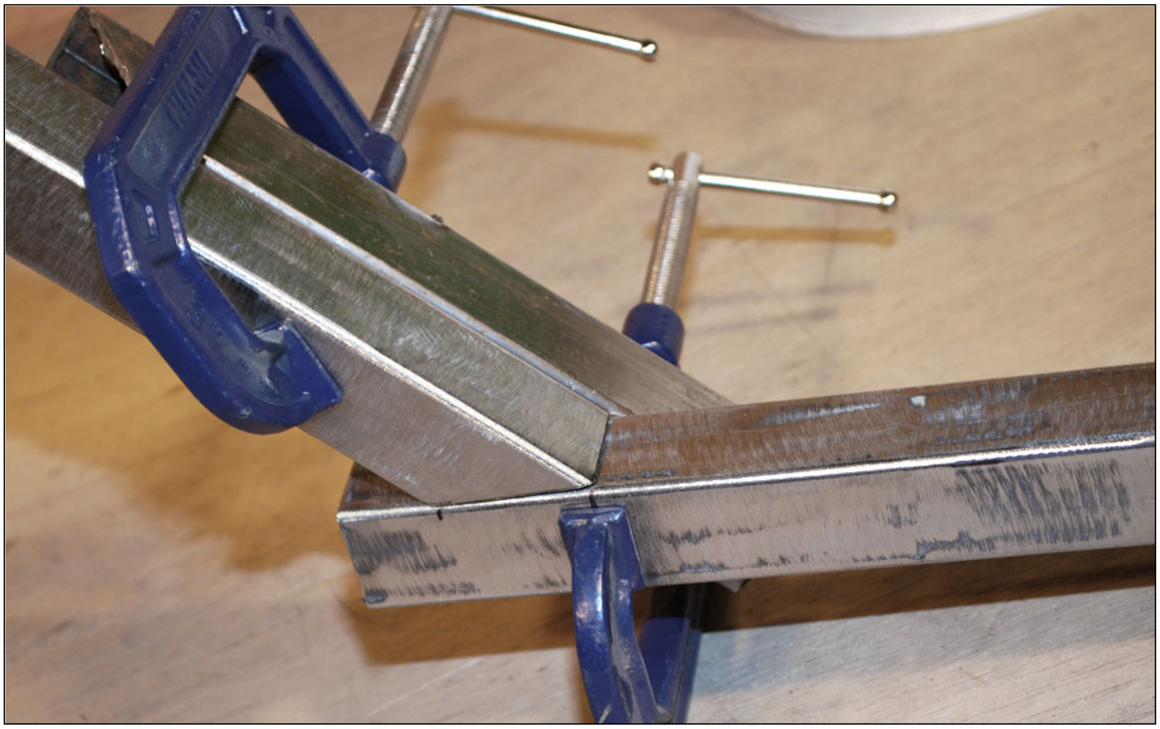

Figure 44 – Using a straight edge as a makeshift jig

Since all of your frame angles are already perfect, the only concern when joining the frame tubing will be vertical inline alignment. To make this job much easier, just use a pair of clamps and a straight tube to “jig” the parts together as shown in Figure 44. You can weld three sides with the clamps installed, and end up with a perfectly aligned frame this way.

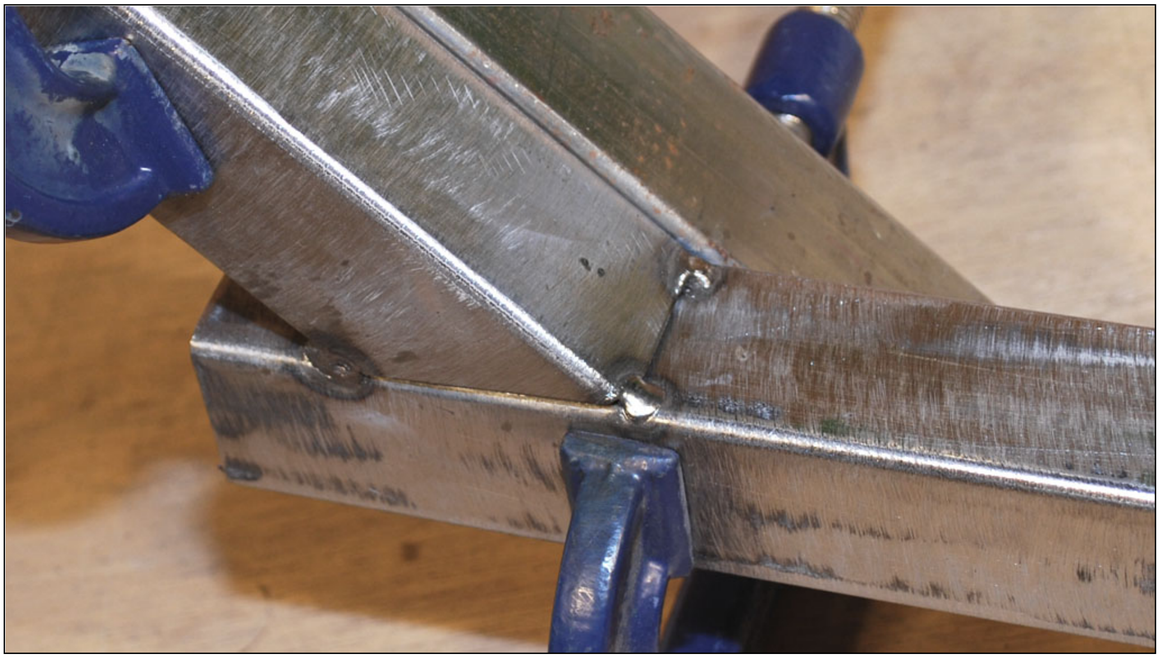

Figure 45 – Start with corner tack welds

Even with the jig holding the tubes in place, the order of welding becomes important to minimize distortion. Start by placing tack welds in all of the corners that are accessible to your welding rod and then check the angles one last time. Figure 45 shows the rear seat tube placed about 1 inch from the end of the center boom tube. Do you remember which tubes are which? Just thought I would ask!

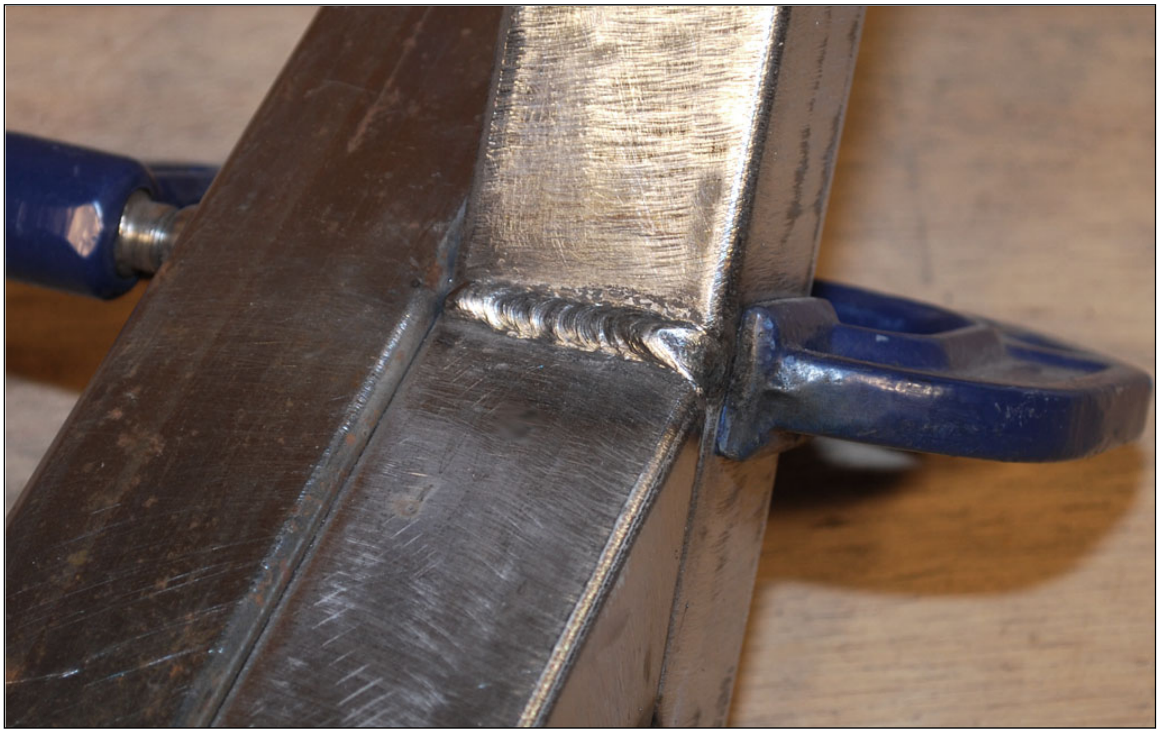

Figure 46 – The top and bottom welds are first

To minimize side to side distortion, the top and bottom of the joints are to be welded first as shown in Figure 46, using the clams and other tubing as a jig.

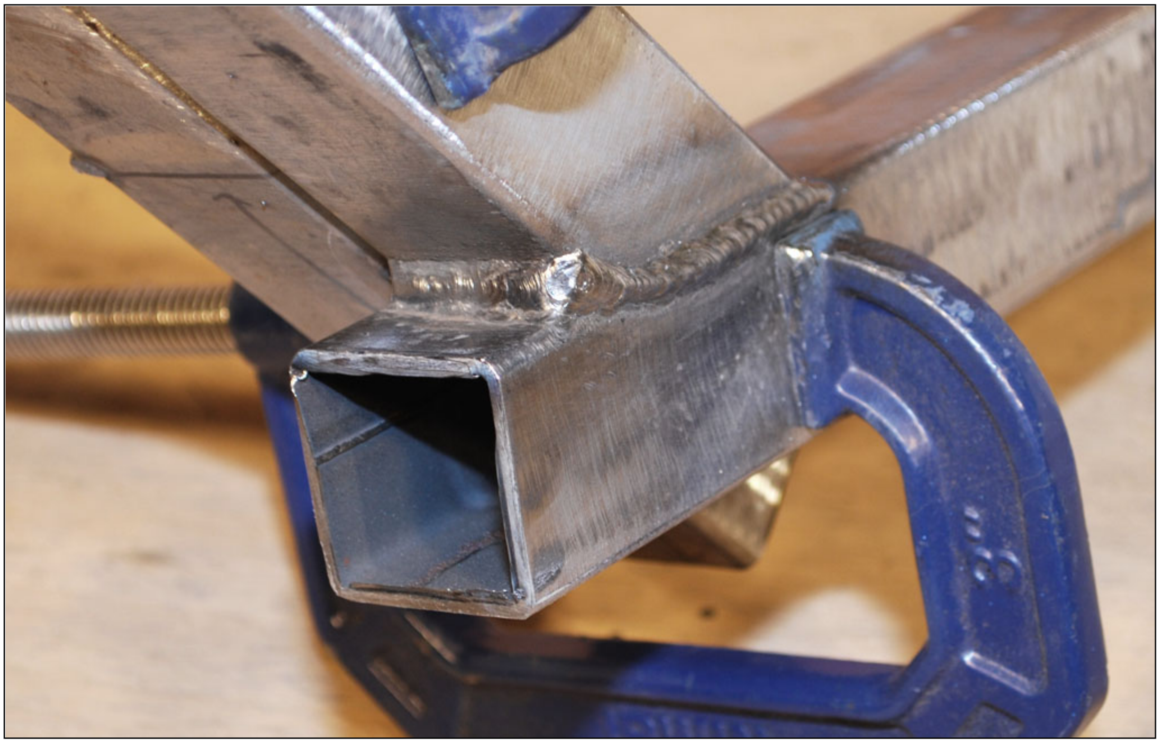

Figure 47 – Welding the inside corner

The inside corner will be a bit more of a challenge to weld, and might take more than one pass to get fully filled. I had to make two passes to fill in all of the gaps using my basic AC arc welder.

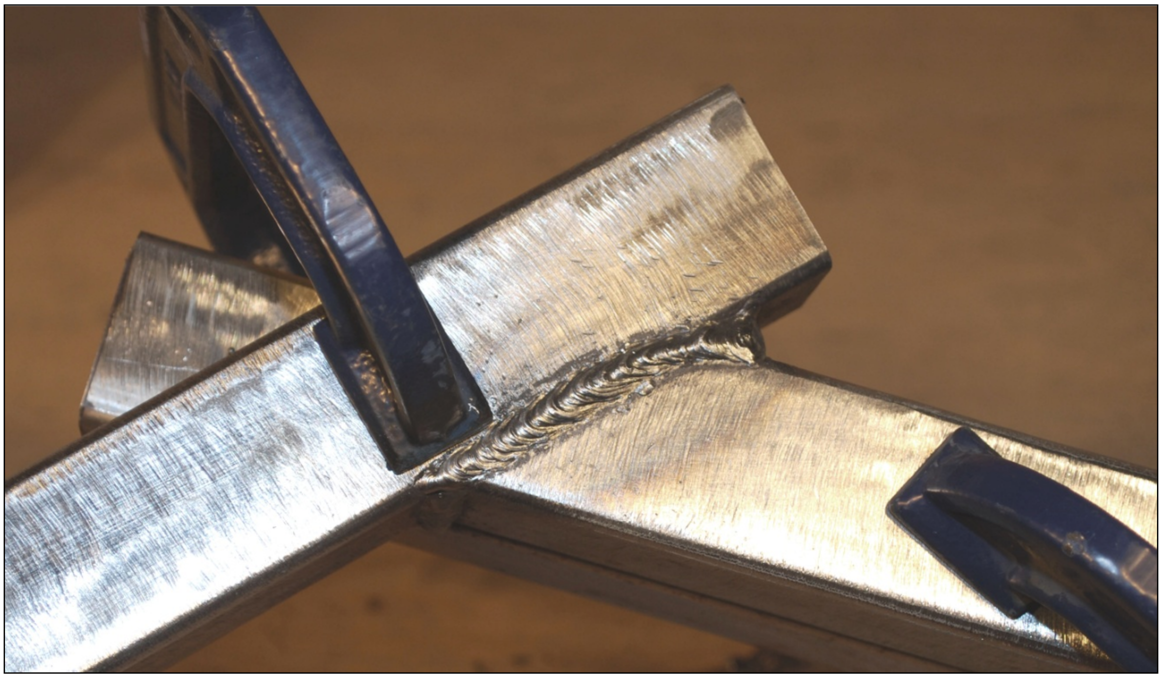

Figure 48 – The sides of the joint are done next

The open side of the joint can be welded after the top and bottom have been welded as shown in Figure 48. You will need to remove the clamps to get to the other side, and clamping the welded side will be impossible, but that’s OK, since the welded side will be holding the joint secure now.

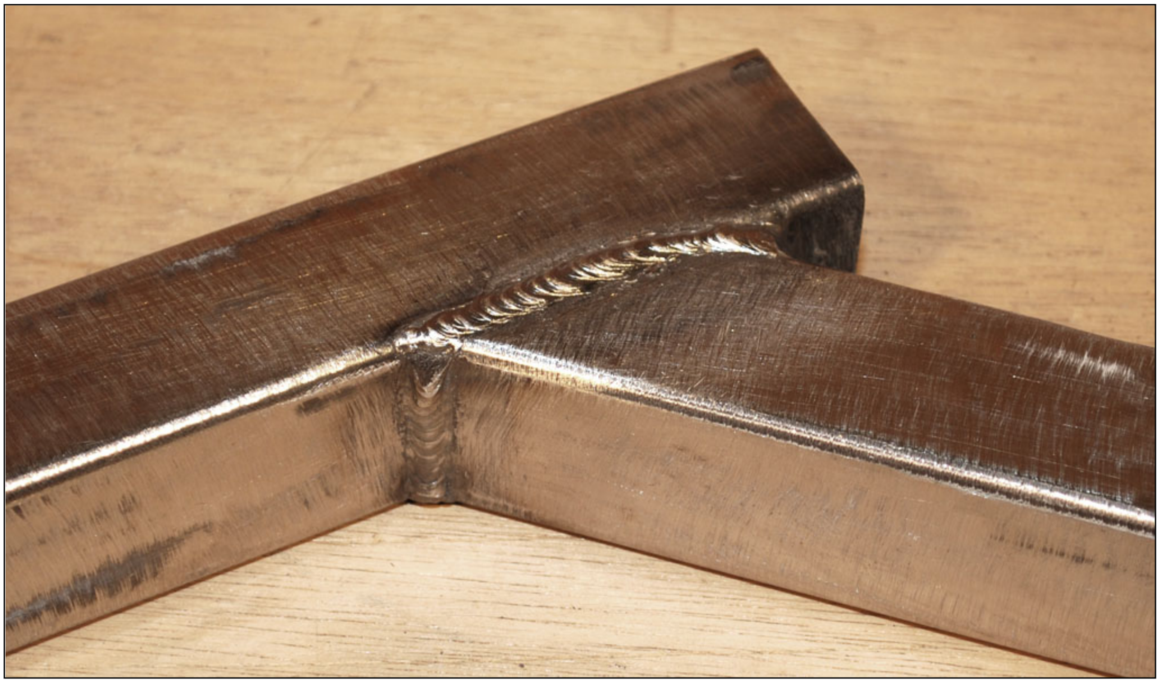

Figure 49 – The seat tube and center boom welds complete

Since this joint is one of the most important structural joints in the frame, ensure that all holes are filled and that the joint is completely welded all the way around. If you are over 200 pounds, or don’t fully trust your welds yet, you can add a few triangular gussets along the sides of the frame just to strengthen the joint, but this will likely not be necessary. Figure 49 shows the completed joint between the rear seat tube and the center boom tube.

Cap Tubing Ends

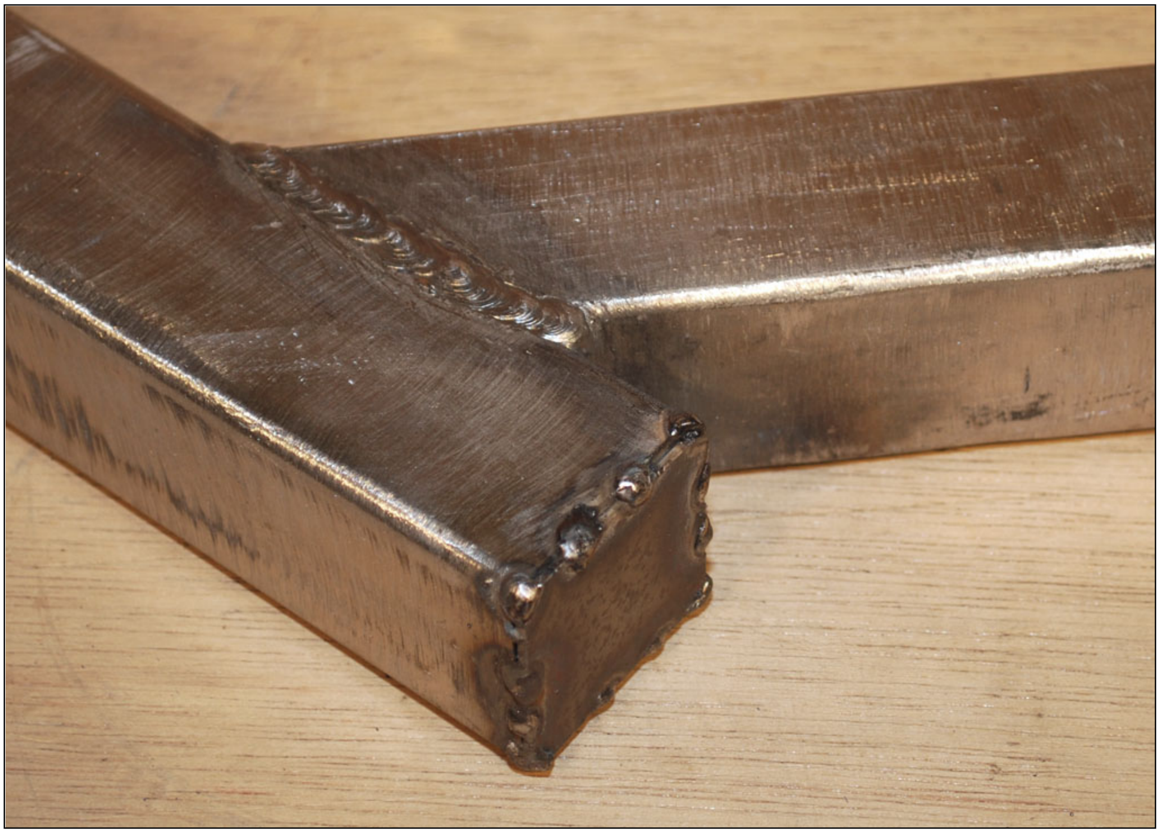

Figure 50 – Capping off the open center boom tube

To give the frame stiffness, the open end of the center boom tube must also be capped. As a general rule, all open ended tubing will need to be capped, and is certainly worth the effort when making your final design look professional. A bit of scrap tubing was butchered for the 1.5 by 1.5 inch piece shown tack welded to the open tube in Figure 50.

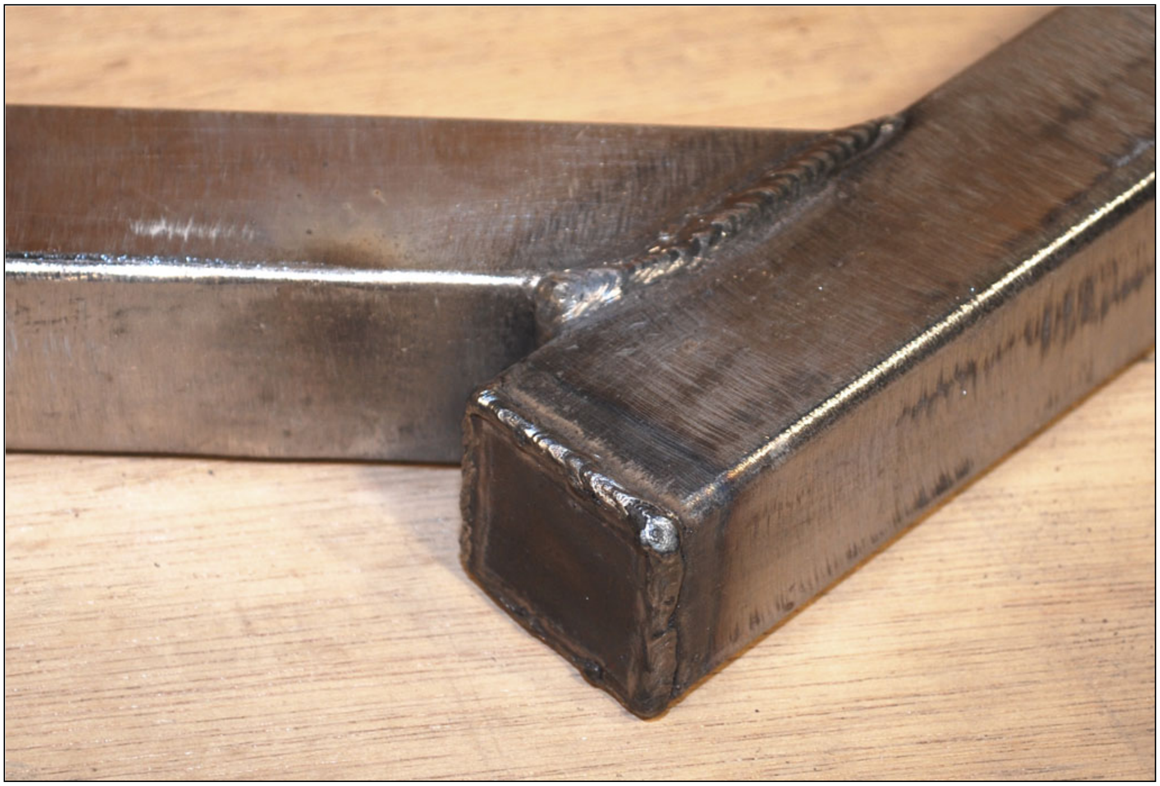

Figure 51 – End cap welded all the way around

When welding the end caps, you can turn down the current and just take your time going around the joint as shown in Figure 51. The goal is to leave as few gaps as possible so that the ‘repair” work after grinding the joint flush will be minimal.

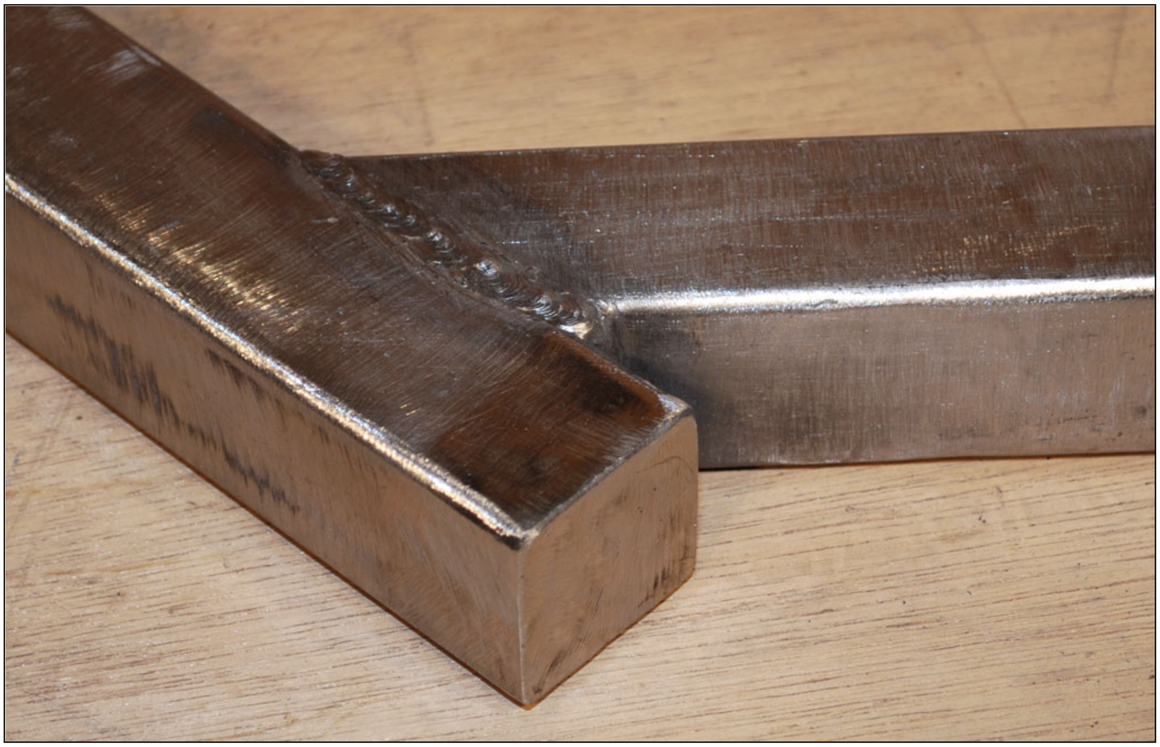

Figure 52 – End cap fully ground clean

The center boom end cap is shown completely welded and ground clean in Figure 52.

Join Rear Seat to Rear Forks

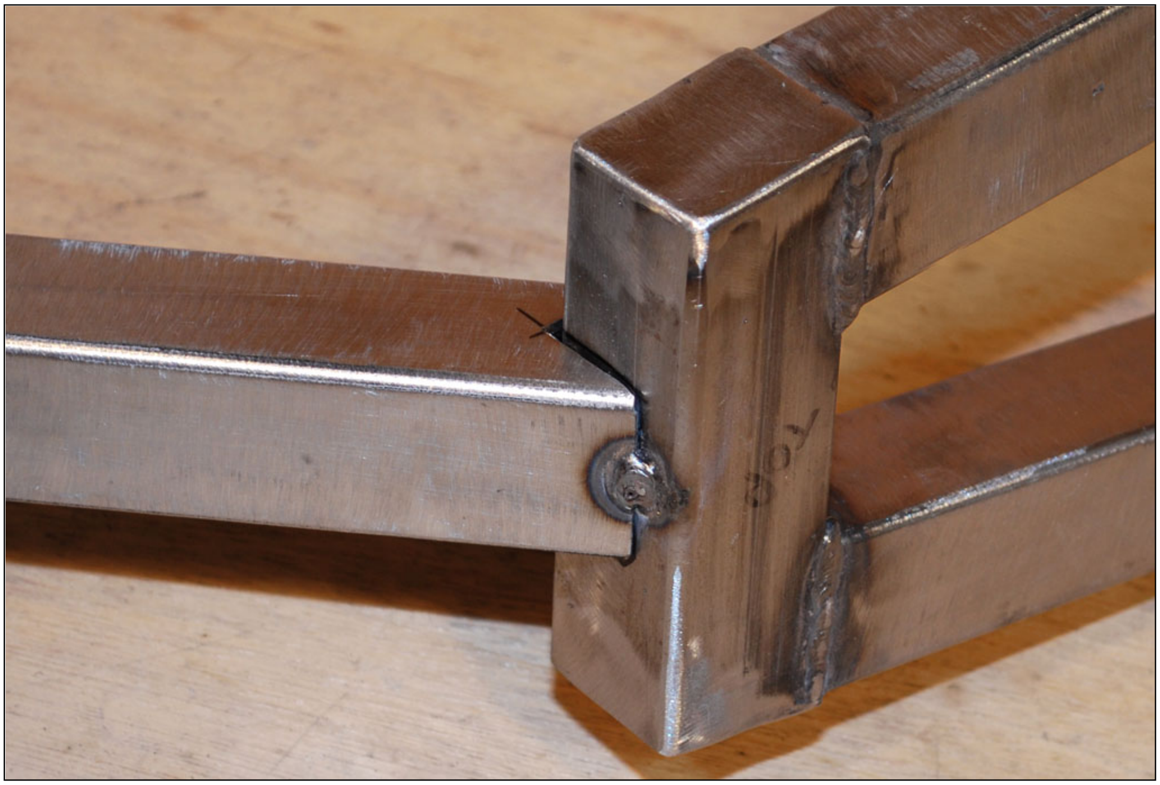

Figure 53 – Joining the rear seat tube to the rear forks

The next step is to weld the rear fork assembly to the top of the rear seat tube as shown in Figure 53 so that it is in the center. I recommend that you add a single tack weld, and then place the frame back up on the blocks just to ensure that the ground clearances remains correct.

If the triangular cut is not perfect, there will be an angle change, so checking with the blocks is a good idea. I usually go one step further and make a second tack weld on the other side while the frame is up on blocks just to secure the angles. As for side-to-side inline angles, those can be fine tuned later.

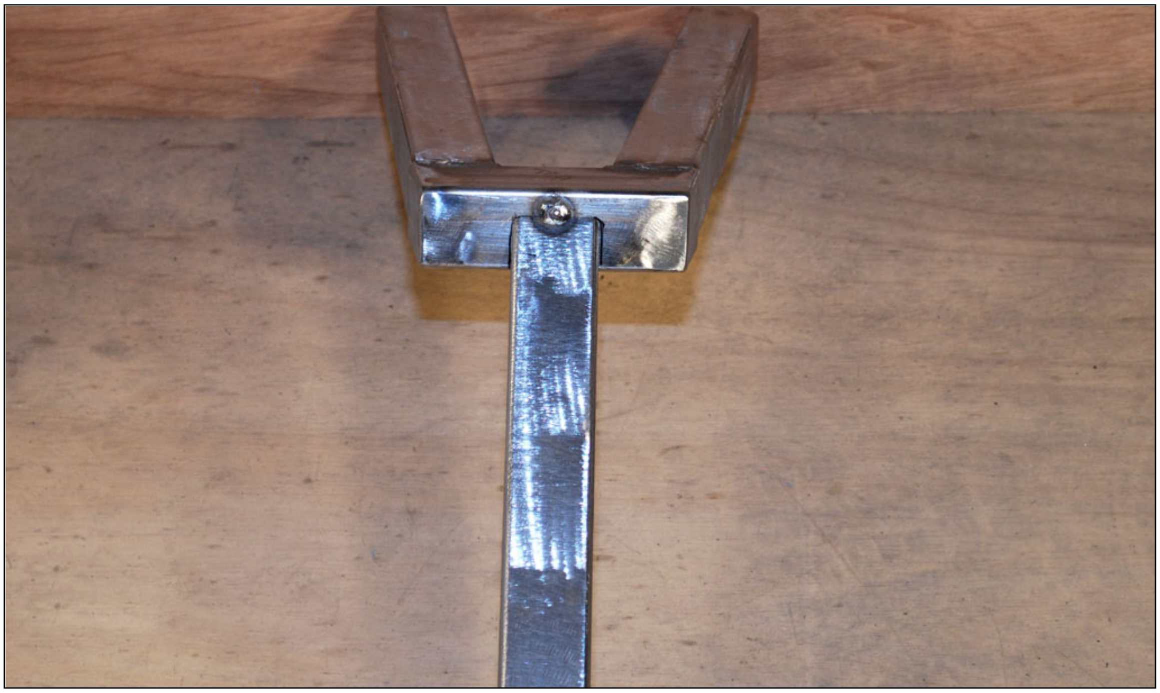

Figure 54 – Checking the side-to-side angle

With the top and bottom of the joint tack welded to secure the angles, you can then move the frame off the blocks and work on the side to side angle as viewed from the position shown in Figure 54. The small fork joining tube should form a perfect 90 degree angle with the rear seat tube so that your rear wheel will be perfectly inline with the rest of the frame.

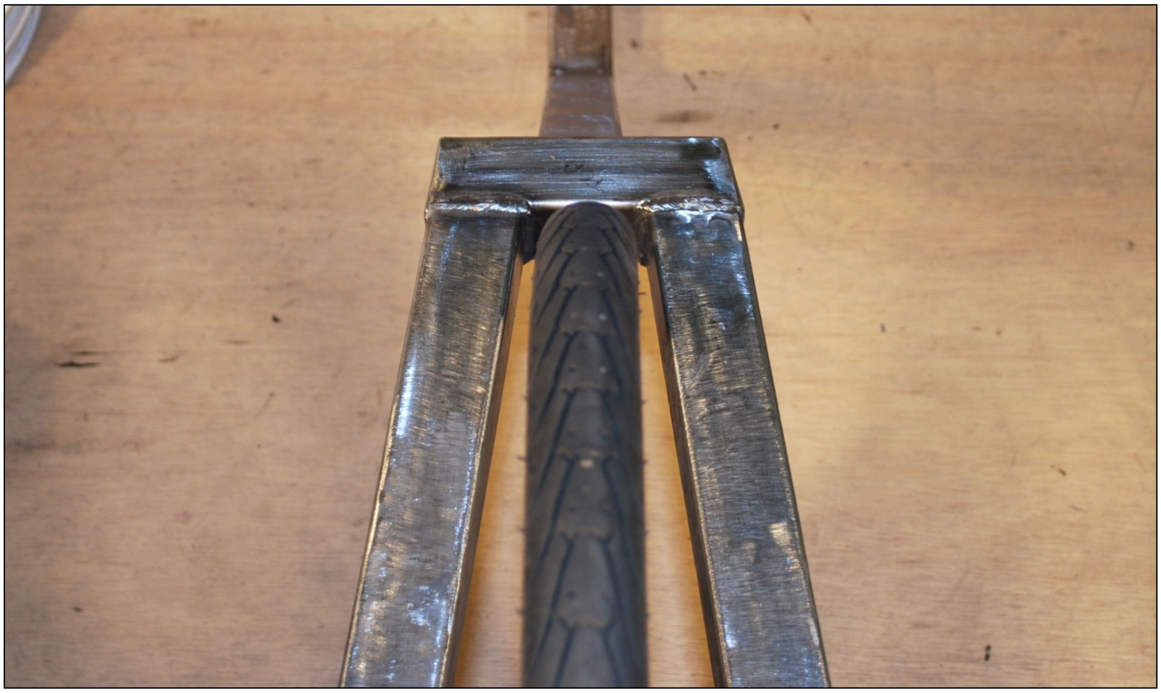

Figure 55 – Using the rear wheel to check angles

To further check the angles, install the rear wheel and look down the frame as shown in Figure 55 to ensure that the wheel is perfectly inline with the rest of the frame tubing. Although, you can "tweak" the rear wheel in the dropouts later, it's best to make the frame as straight as you can for appearances. If alignment is way out, break one or both of the tack welds and try again.

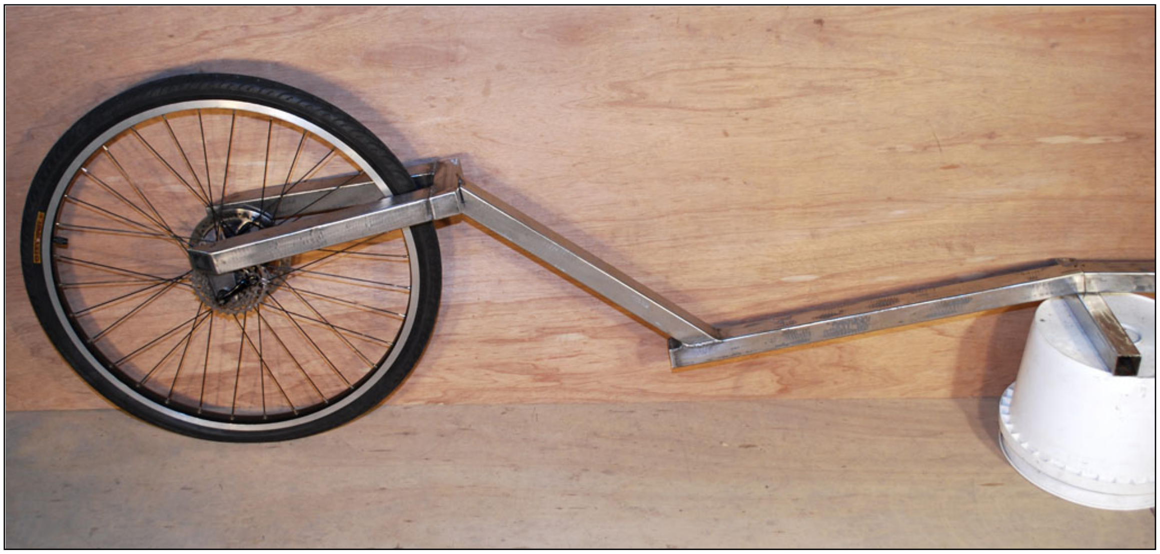

Figure 56 – One last alignment and angle check

Before committing any of the rear fork welds, set up the front of the center boom to the 11 inch ground clearance one more time just to check over the other angles and clearances. With the front of the center boom up on the blocks, the other end of the center boom should be 5 inches off the ground. Looking from the rear of the frame should also show that the rear wheel is perfectly inline with the rest of the frame.

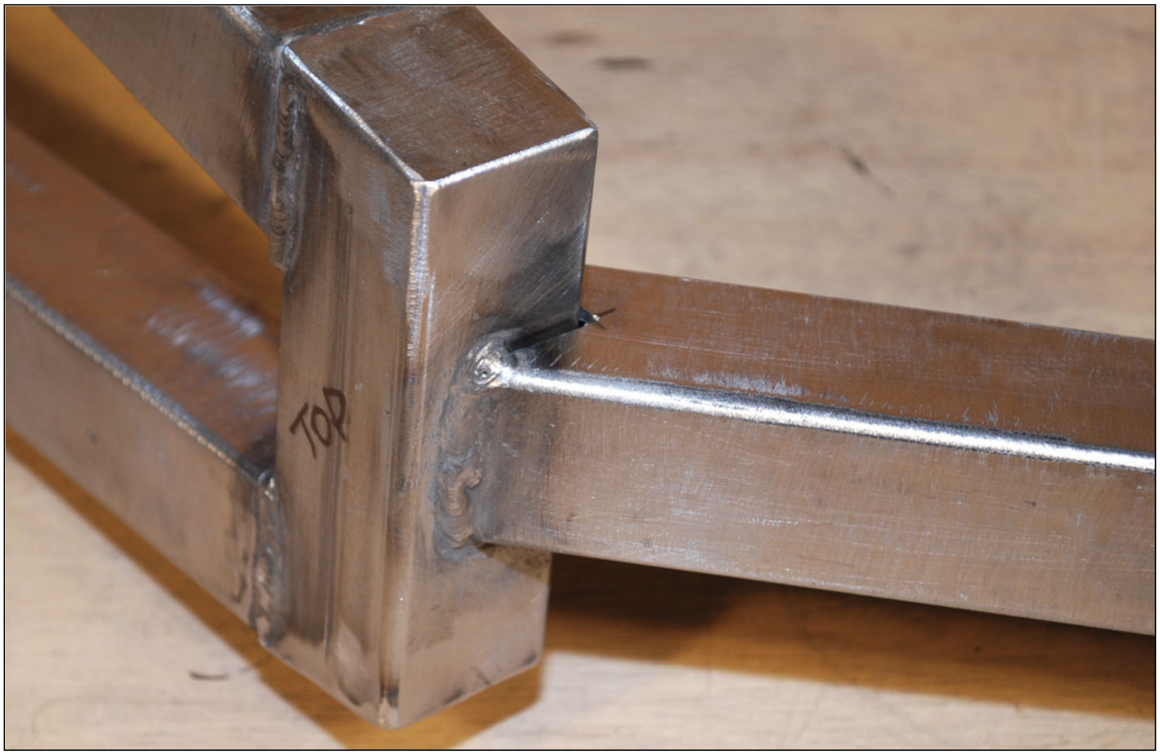

Figure 57 – Start at the top of the joint

Carefully remove the rear wheel, or just leave it on so you can weld the top of the joint without disturbing the angles held by the tack welds. As shown in Figure 57, the top of the rear seat tube and fork assembly weld is done first, followed by the underside of the joint. You can’t easily clamp and jig this weld, so check the alignment once more after the top of the weld has been made.

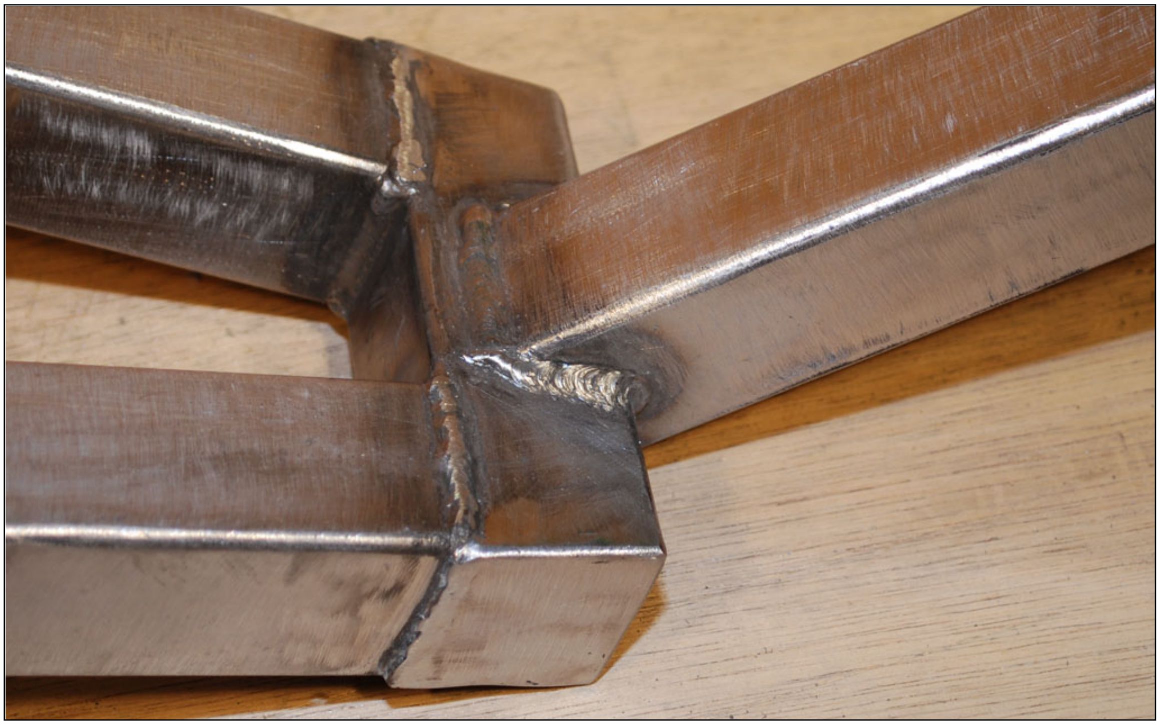

Figure 58 – Welding the side of the joint

The sides of the joint will be completed after the top and bottom as shown in Figure 58. The side welds are not as structural as the top and bottom welds, so you can lower the heat if you want and run a smaller weld to help reduce side-to-side distortions.

Joining Front and Center Boom Tubes

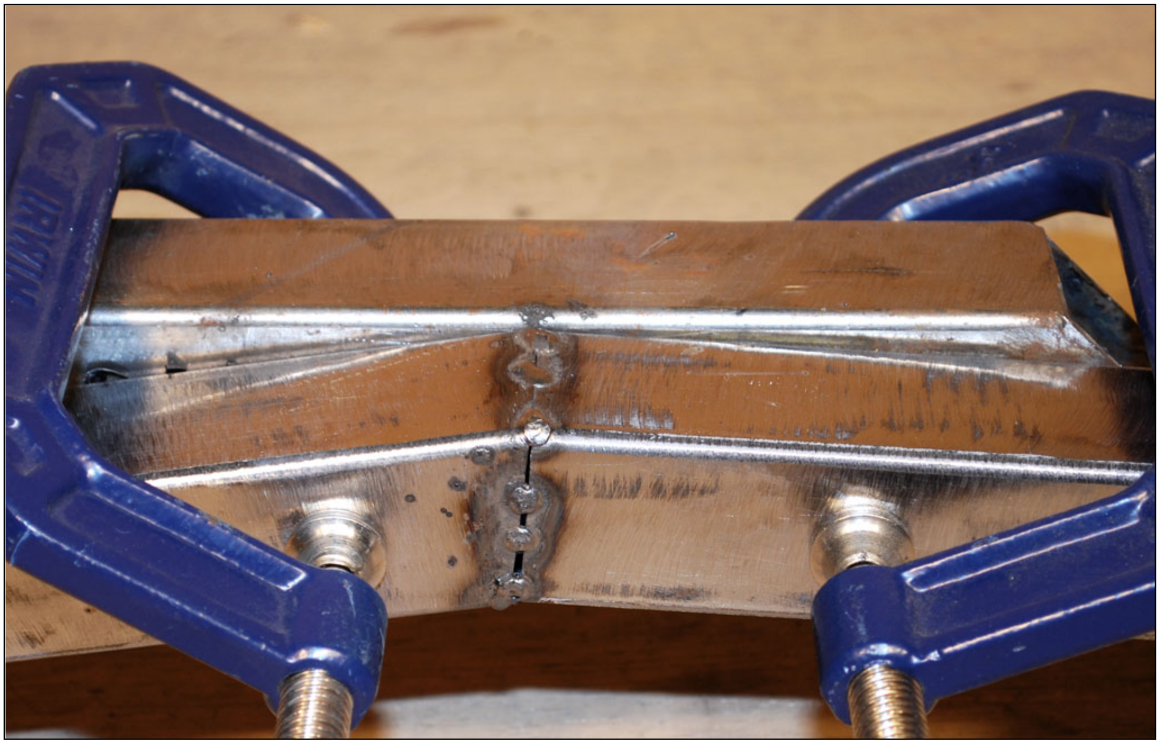

Figure 59 – Joining the front boom and center boom tubes

The joint between the front of the center boom and front boom will be made next, using the clamp and jig method to help keep the frame aligned. As shown in Figure 59, I start with a few tack welds so that I can keep the current up high and get good penetration along the entire joint. This process helps keep burn troughs to a minimum when using an arc welder. This is another joint you want to make sure is done properly, since it will be under a decent amount of stress.

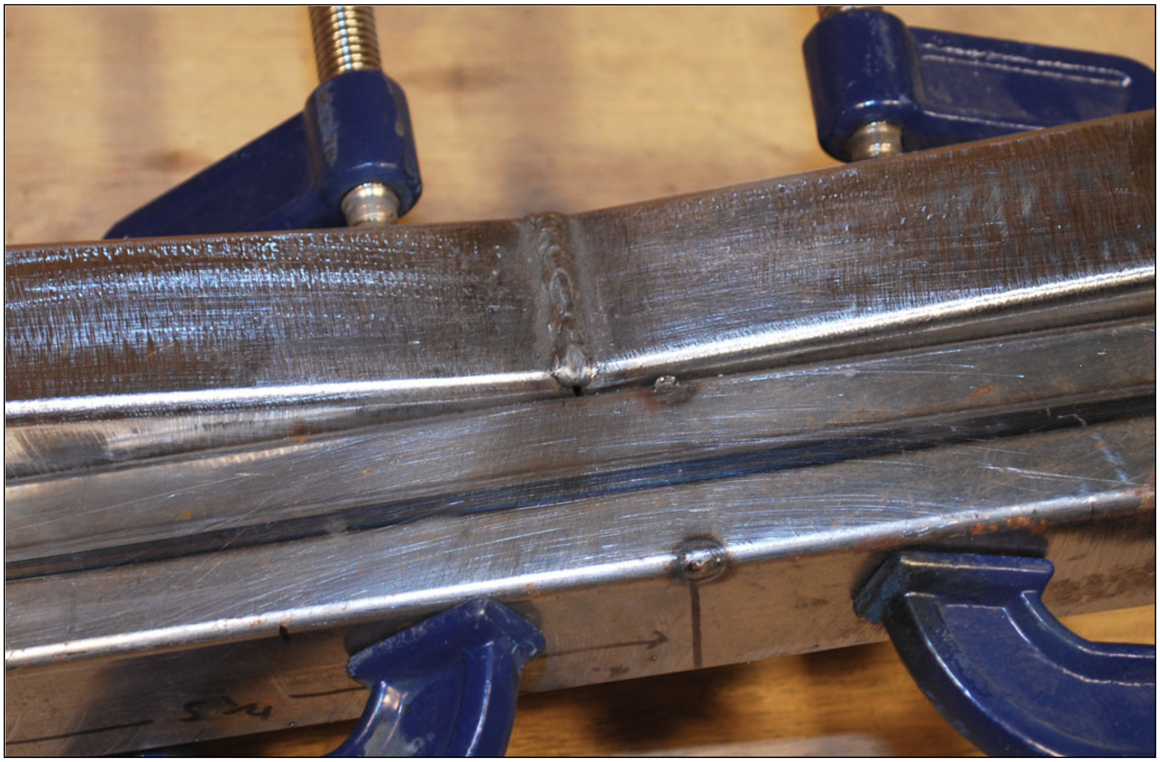

Figure 60 – The same order is always used

Just like the other inline frame welds, the top and bottom of the joint are welded first before doing the side that is not hidden by the clamps. Figure 60 shows the completed weld on the underside of the joint.

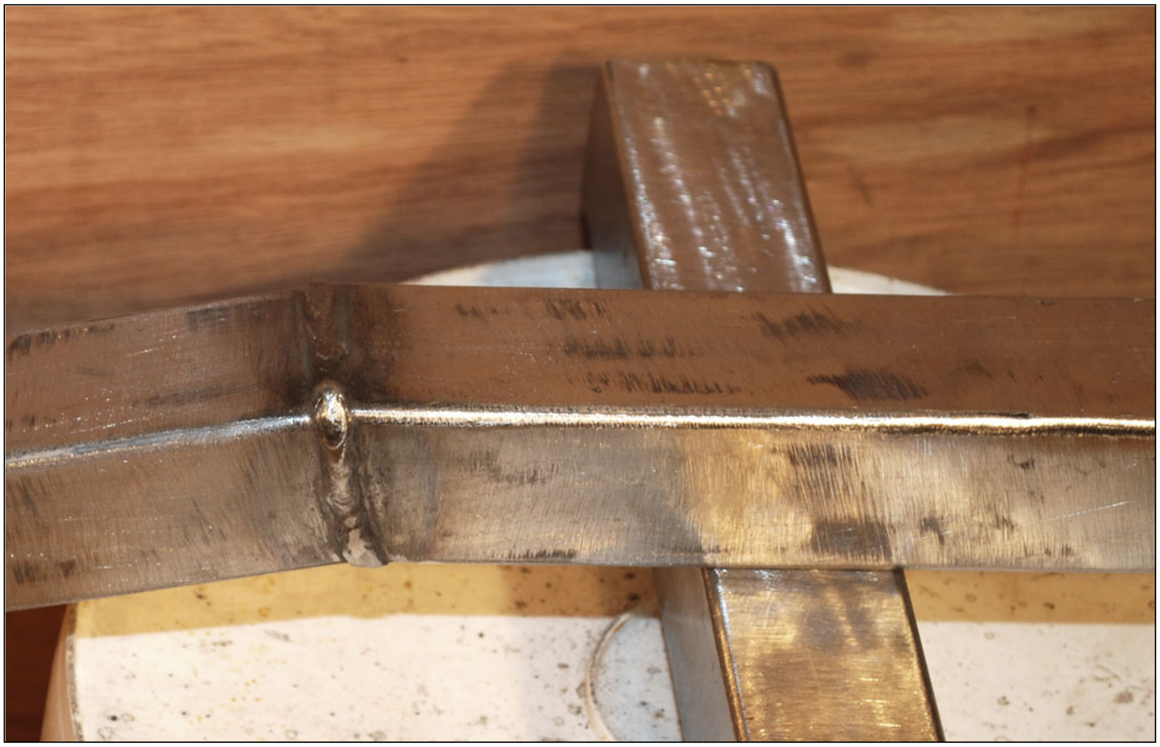

Figure 61 – Front boom joint completely welded

The front boom welds should not be ground flush unless you are confident with your welding ability, as this weld will see quite a bit of stress. If you do decide to grind the area flush with the boom tubing, at least leave the underside of the joint un-ground because that is the most critical weld of all the sides. The completed center boom and front boom weld is shown in Figure 61, propped up for one last alignment verification.

Making the Adjustable Bottom Bracket

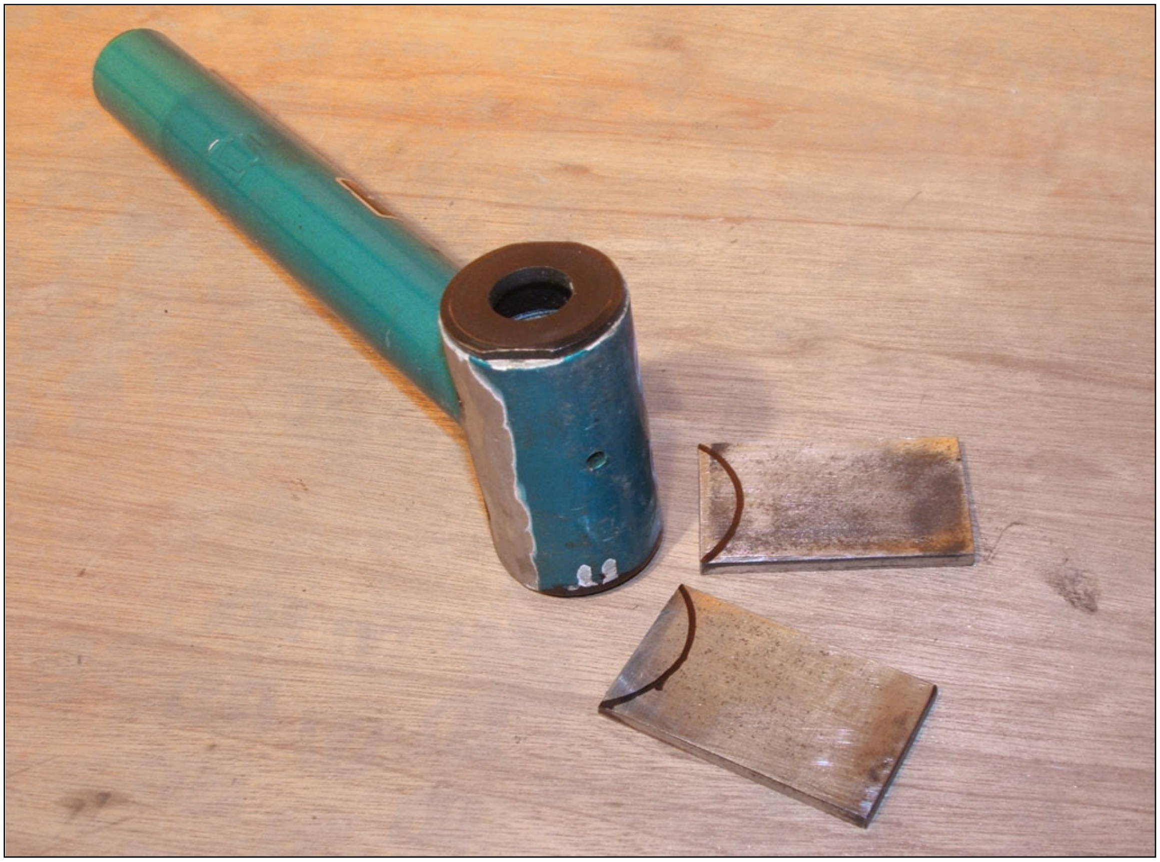

Figure 62 – Adjustable bottom bracket parts

It would be very difficult to guess the exact placement of the bottom bracket for your inseam (leg length) without making a small error. A fixed bottom bracket also means that you could never alter the seat, or adjust the Warrior for anyone but yourself, so an adjustable bottom bracket is the only logical option.

If you cut the bottom bracket from an old bicycle frame, and leave a 12 inch or longer section of the seat tube connected (for the front derailleur), you can create a very functional adjustable bottom bracket with nothing more than a pair of steel plates. The bottom bracket and included seat tube will be mounted to the main boom with a clamp arrangement that allows the assembly to be placed practically anywhere on the boom to allow riders of varying heights to ride the bike. The two plates shown in Figure 62 along with the bottom bracket and seat tube stub will form the sides of the clamp that will hold the bottom bracket against the side walls of the main boom as they are forced together by two bolts.

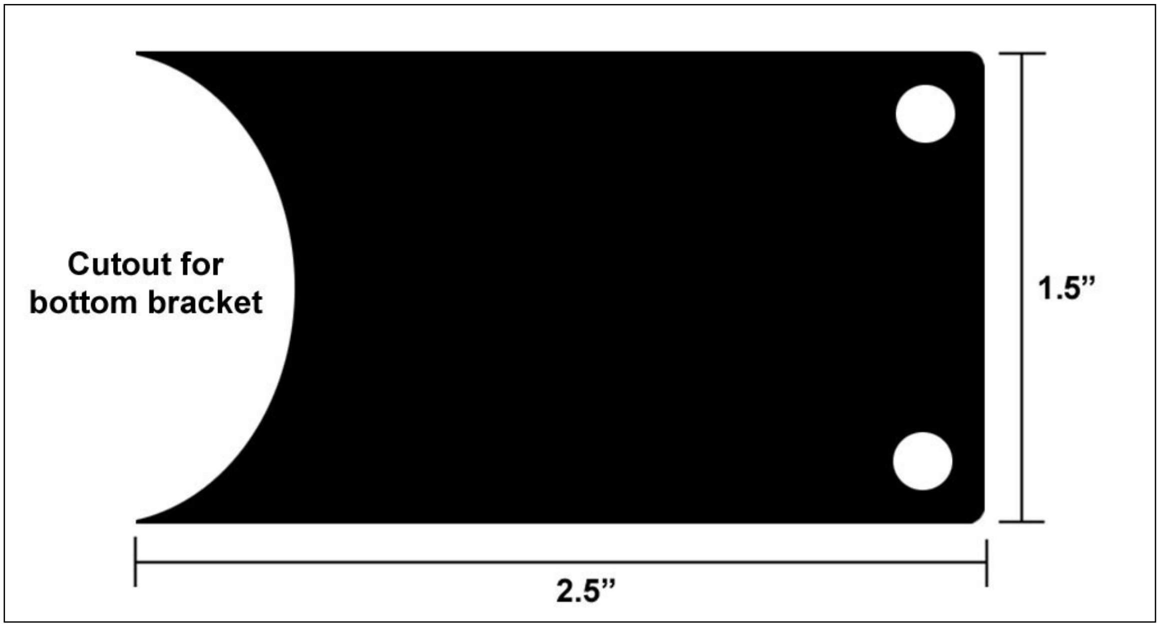

Diagram 3 – Adjustable bottom bracket clamp plates

The bottom bracket and front derailleur tube move together along the front boom, so you do not need to worry about the position of the derailleur over the chain ring. The chain is cut to the perfect length once the bottom bracket has been adjusted for the main rider, but will still allow a few inches of adjustment in either direction without a chain alteration due to the spring loaded rear derailleur. Of course, the difference between a 6 foot 5 inch person versus a 4 foot tall person will likely require some chain adjustment, but this can be done in less than a minute with an inexpensive chain link tool.

Cut two 3/16 inch thick pieces of plate or sheet to make the shapes as shown in Diagram 3. The round area is cut to conform to whatever size bottom bracket you decided to go with, and the two bolt holes will be drilled for 3/8 inch bolts. The bolt holes are drilled at the edge of the plates so that there is 1/8 inch of material between the hole and edge of the plate. These two plates will form a "vice" that will clamp the bottom bracket to whatever position on the main boom you want.

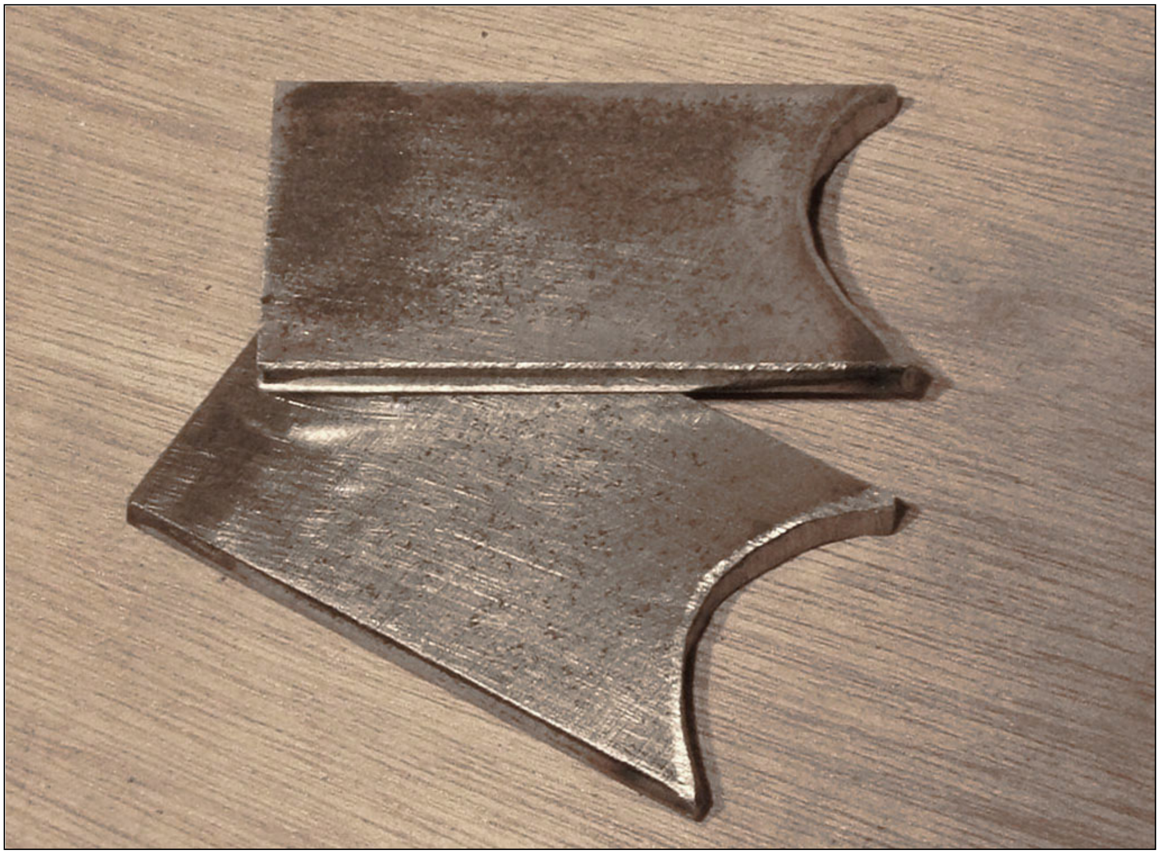

Figure 63 – The plates will conform to the bottom bracket

Trace around the bottom bracket shell to draw a line on the plates as shown earlier in Figure 62. The marker line should meet the corners of the plate to ensure that you don't cut out too much off of the plate when grinding out the rounded area. If you take too much metal away from the plate, there will not be enough room between the bottom bracket and the clamping bolts for the main boom.

When grinding out the traced circular area for the bottom bracket as shown in Figure 63, place both plates in the vice so they can be done at the same time; this will ensure that both plates are exactly the same size. Try to make the gap as small as possible around the bottom bracket shell so that there is less distortion as the plates are welded. If the bottom bracket becomes overly distorted, it will be a serious challenge trying to screw the hardware back into the bottom brackets without stripping the threads.

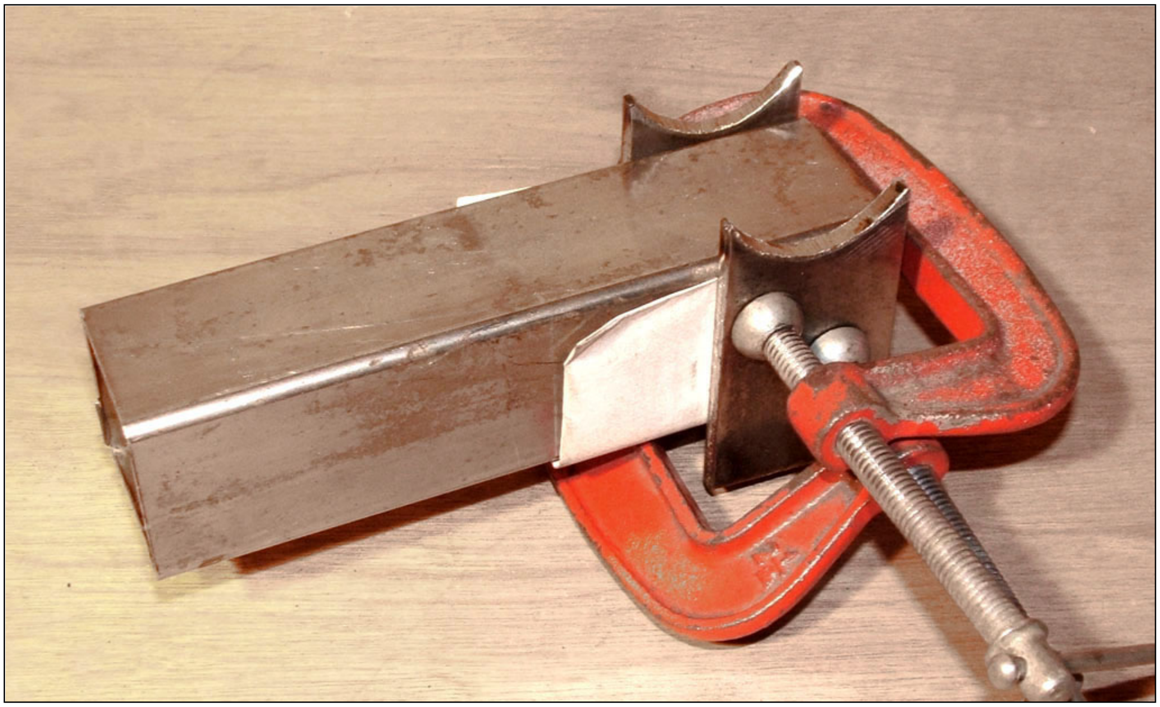

Figure 64 – Clamping the plates for welding

In order to get the two plates aligned with each other and at the correct spacing, a bit of frame tubing can be clamped between the two plates as shown in Figure 64. This will allow you to set the bottom bracket into the correct position for tack welding, as well as ensure that both plates are aligned with each other so the bolt passes easily through both holes.

I also placed a sheet of paper between each plate and the side wall of the tubing in order to allow a little clearance between the clamp plates so that the unit is not so difficult to slide when making adjustments. Without the small gap, it is easy to scratch the paint if you plan to move the bottom bracket around a lot.

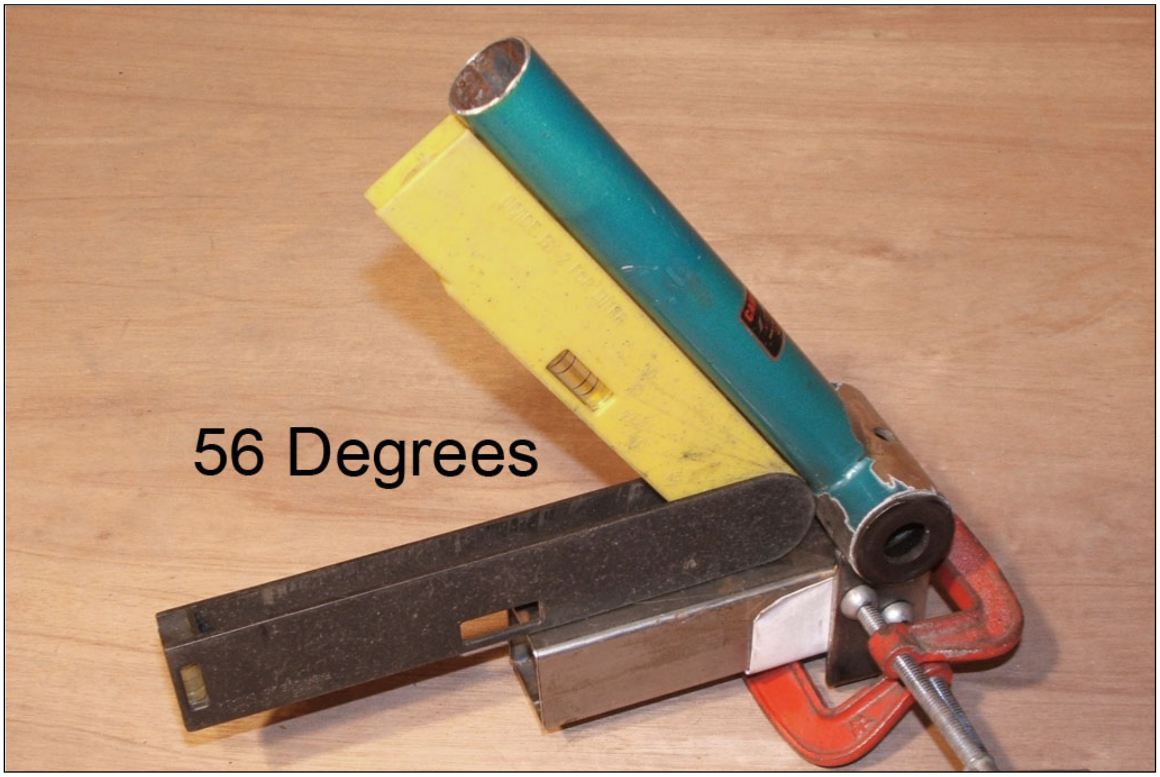

Figure 65 – Proper front derailleur tube angle

As shown in Figure 65, you can use an adjustable square set to the required 56 degrees in order to set up the bottom bracket and derailleur tube to place two small tack welds at the top of the joint. It may be a bit tricky to get the first tack weld in place while holding the bottom bracket in position, but once this is done, the rest is easy.

With the piece of frame tubing as a guide, you will automatically have the correct distance between the plates. Now, you will need to ensure that there is approximately equal distance between each plate and the edges of the bottom bracket. In other words, the bottom bracket will be in the center of the main boom as viewed from above.

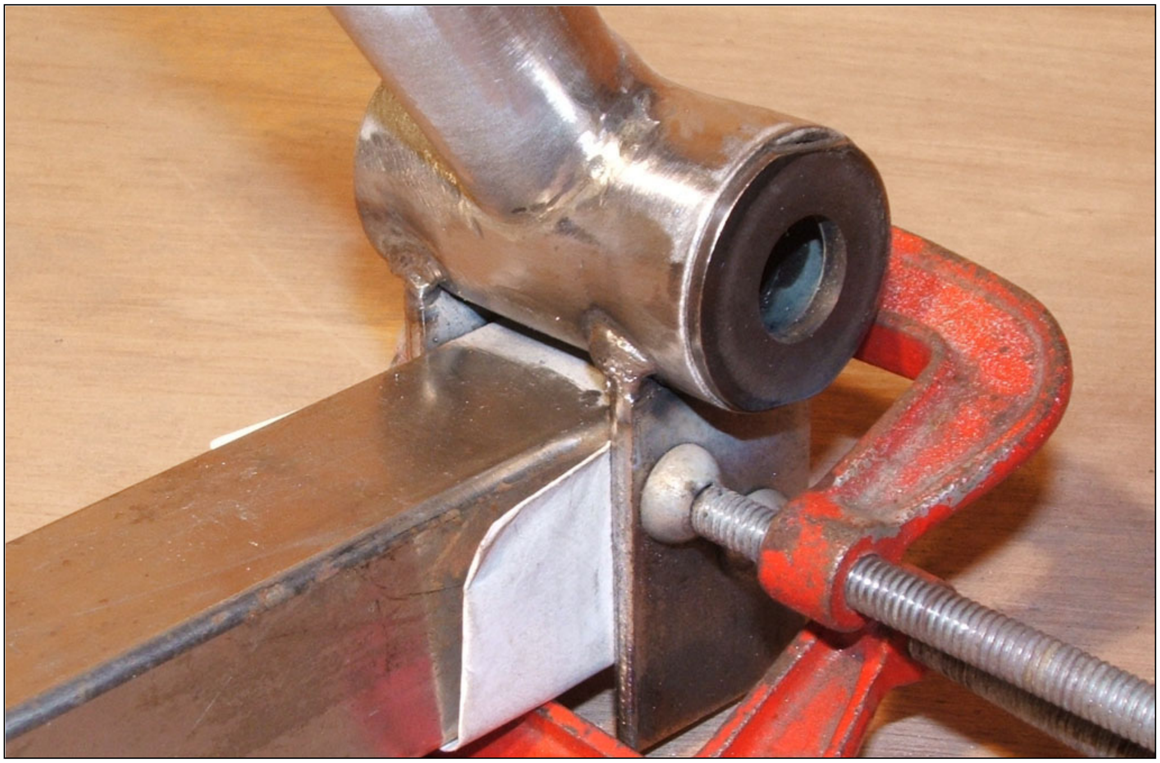

Figure 66 – Clamp plates tack welded to the bottom bracket

Figure 66 shows the first tack welds done at the top edge of the plates in order to secure the parts together. Ensure that the derailleur tube angle is close to 56 degrees and that the bottom bracket is at 90 degrees to the square tubing. You can also move the clamps to hold the plates in a position that will allow you to weld around the entire joint.

Also, welding is only done on the outside of the joint, not between the plates. If the inside of the joint is welded, the weld bead will not allow the bottom bracket to sit directly on the frame tubing and could cause alignment problems. Because of the way the clamp system works, there would be no added benefit from welding the inside of the joint anyway.

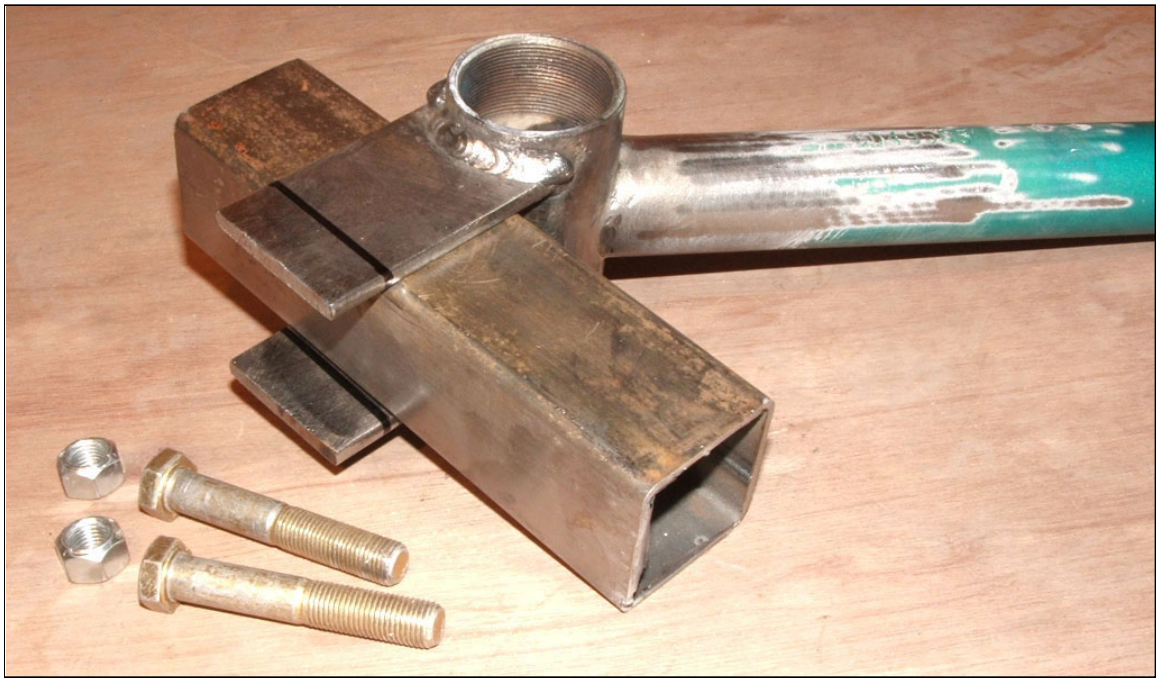

Figure 67 – Marking a line for bolt hole drilling

The two plates will form a vice-like grip on the frame tubing when the 3/8 inch bolts are tightened. In order to drill the holes into the plate, draw a line that represents the bottom corner of the frame tubing as shown in Figure 67. Now you can punch and drill the holes using the line as a guide that will allow you to ensure that the holes stay below the line. If the holes are not below the line, you will not be able to pass the bolt through both plates because it will hit the frame tubing instead.

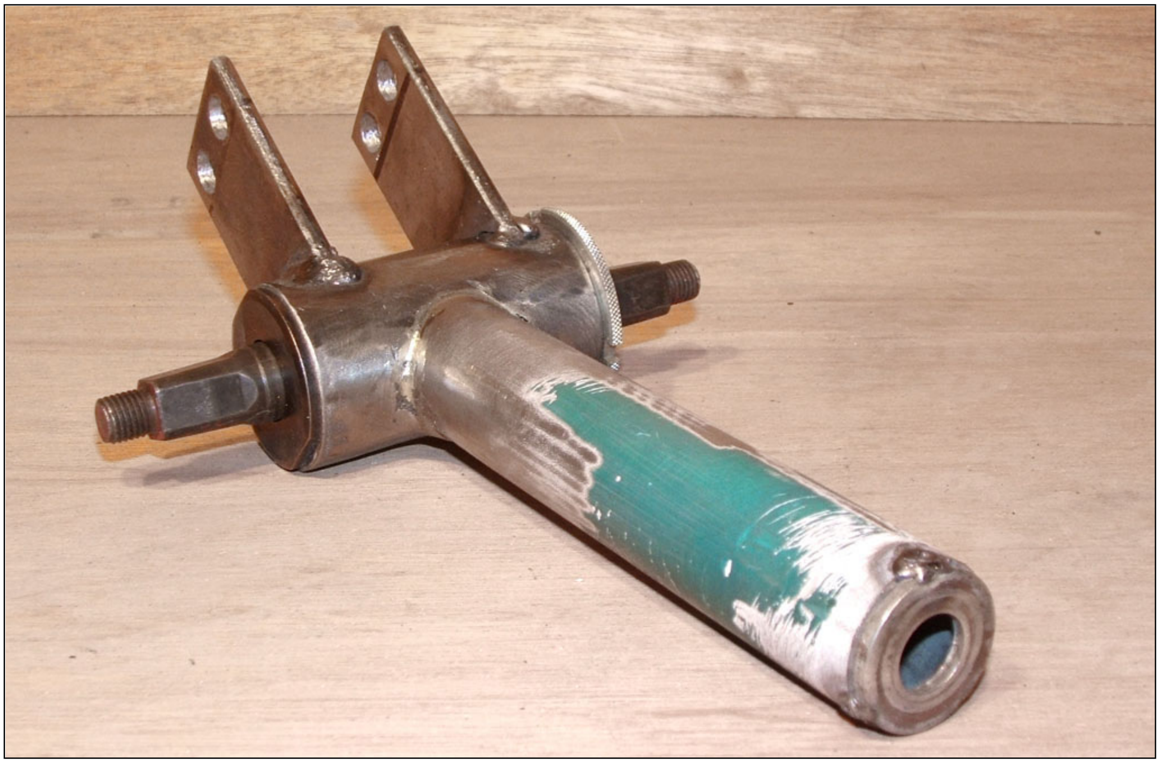

Figure 68 – Capping the end of the derailleur tube

With the derailleur tubing cut to length, it is a good idea to cap off the open end of the tubing so that it looks better and keeps any moisture out. As shown in Figure 68, a washer is welded over the end of the tube and then completely filled in around the joint and the hole. To fill in the washer hole, several passes are made around the edge until completely covered in weld metal.

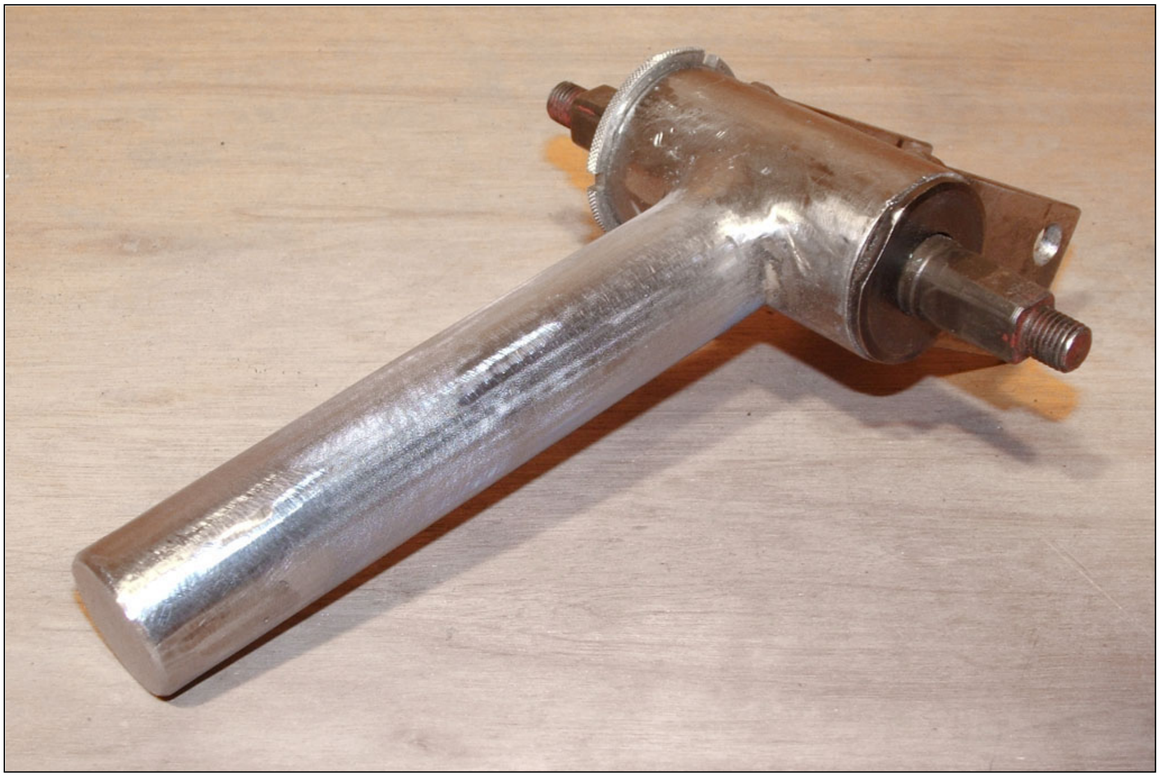

Figure 69 – Completed adjustable bottom bracket

After welding the washer in place and grinding the area clean, you can't even tell the tube shown in Figure 69 once had an open end. Going the extra mile can make your final product look very professional, possibly even better than some mass produced machines, since they might have simply capped the hole with a plastic plug to save time and costs.

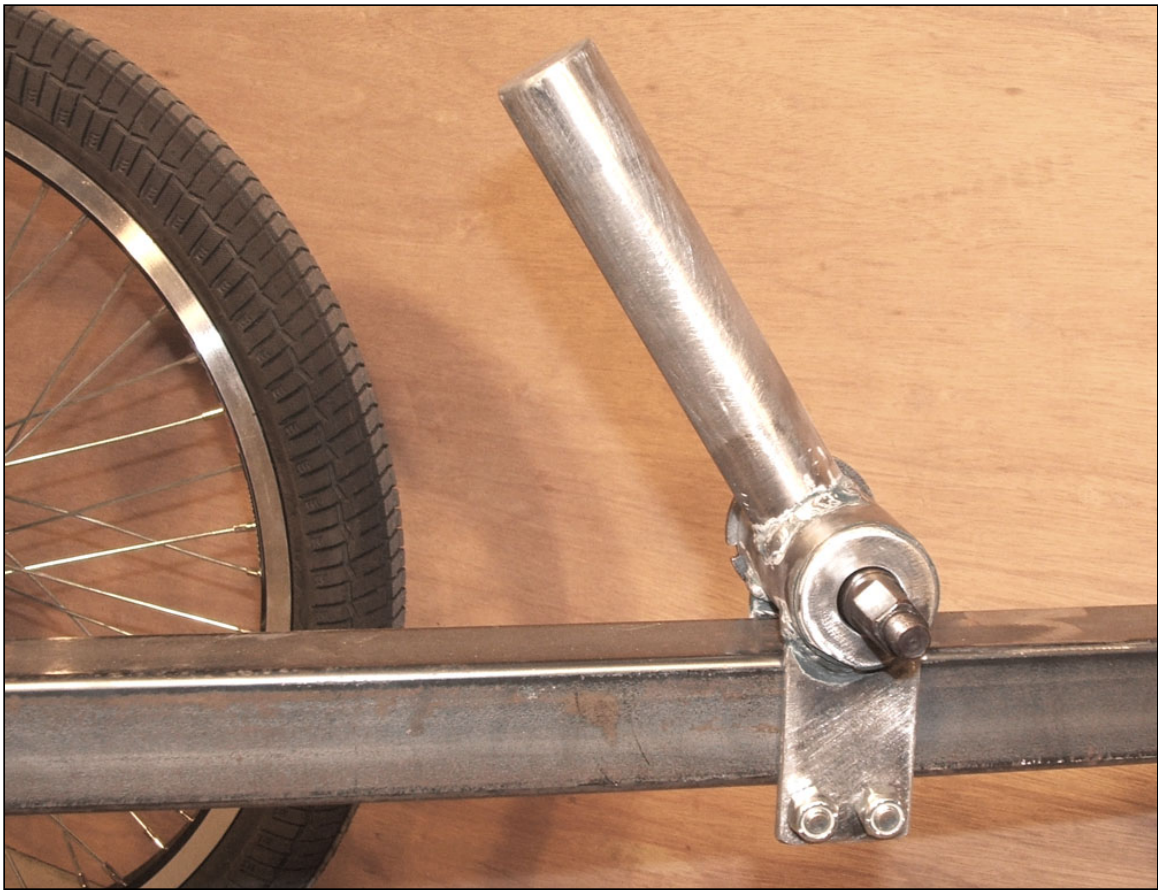

Figure 70 – Adjustable bottom bracket installed

Figure 70 shows the sliding bottom bracket secured to the frame tubing. Notice that the bolts are fairly close to the underside of the frame tubing thanks to the guide lines used to drill the holes. The derailleur tube is very close to the 56 degree angle as well. Tighten the bolts enough so that you can't force the bottom bracket to move by pulling on the derailleur tube, but not too tight, or you may actually crush the frame tubing. Don't bother greasing up the bottom bracket bearings just yet, as you will want to do that after the priming and painting is completed.

Installing Hubs and Disc Brakes

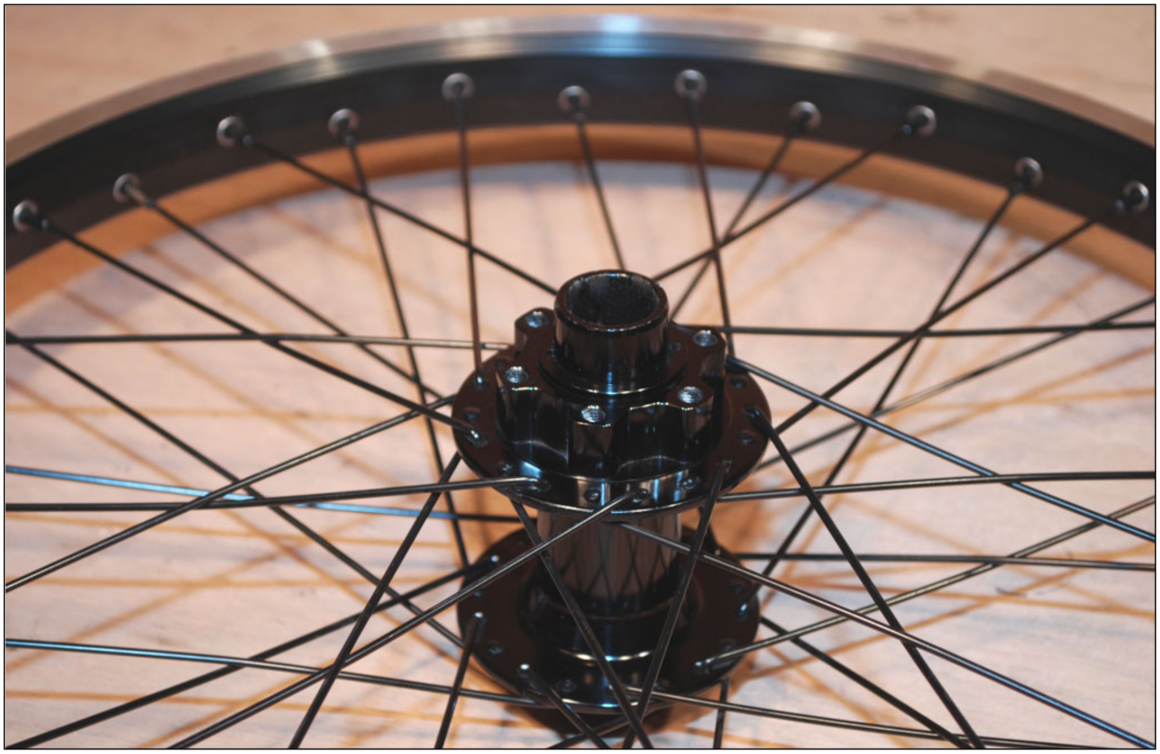

Figure 71 – The front hubs are 20mm hollow axle types

One of the largest mechanical challenges when building a tadpole trike is how to affix the front wheels by holding only one side of the axle. Obviously, a typical 10mm or 12mm threaded axle will fail horribly in minutes, so something much stronger will be necessary. Add to this complexity, the addition of front braking, and you have some real design challenges to deal with. Many professional trike manufacturers actually machine their own custom hubs, or make modifications to expensive hubs to add larger bearings. Fortunately, there are several inexpensive and simple options that you can use here.

On another tadpole trike we designed, the StreetFox, I opted to use 14mm BMX hubs and then run another tube around the wheel so that standard caliper brakes could be used. This method is certainly the least expensive when it comes to brake parts, and 14mm axles are very common on 20 inch BMX wheels.

The Warrior has been designed to be the ultimate performance trike, so disc brakes were chosen for the two front wheels and optionally the rear wheel. This meant that 14mm BMX hubs were of no use because there was only a single manufacturer that made them with disc brake mounts, and they were very expensive. Since I only use common and inexpensive parts in my plans, another option was necessary.

Figure 71 shows the perfect hub choice for a tadpole trike that uses front disc brakes – the 20mm hollow axle hub. These hubs are common on mountain bikes, so you can easily find them with 36 holes (recommended), and they are not expensive (usually in the $25 to $50 range). The only issue is that they are not normally laced into 20 inch wheels, so you will have to ask your bike shop lace them for you, or try to build the wheels up yourself.

As for rim choices, any double wall medium quality rim will do, and if you can, try to match the color of the front and rear rims for appearances. The hubs shown in Figure 71 are “Formula” brand, and cost me about $30 each. You will need two front hubs.

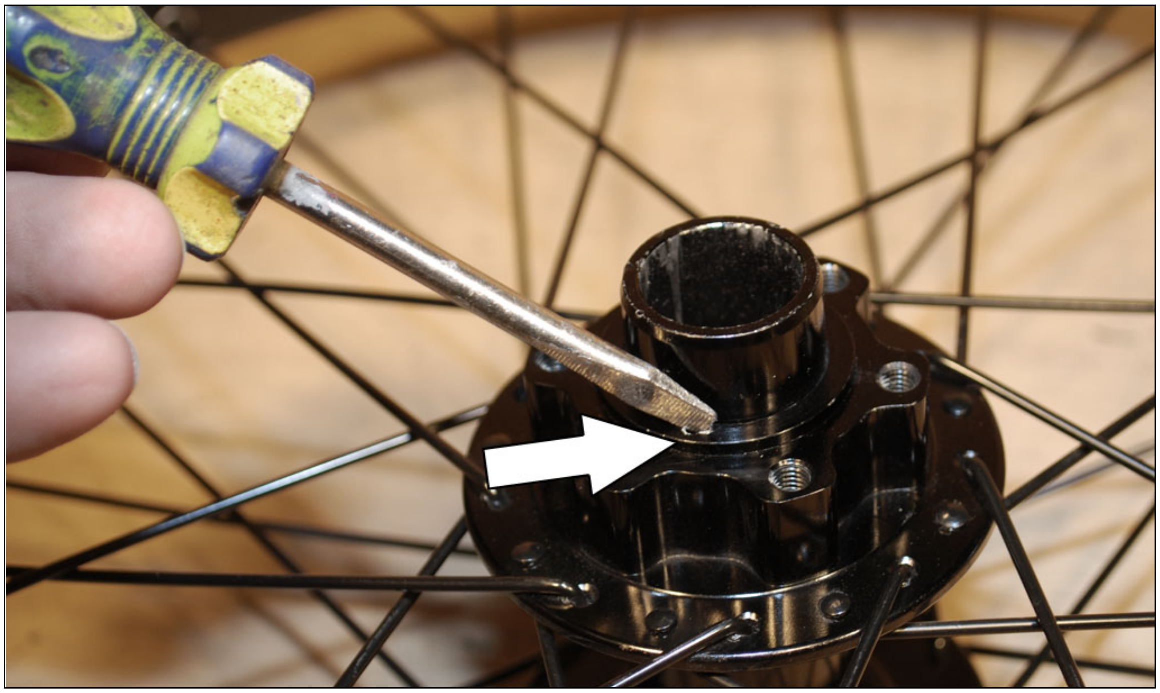

Figure 72 – Removing the dust caps

There are several styles of 20mm hubs, but they all have one thing in common – a pair of cartridge bearings with an inside diameter of 20mm on each side of the hub. Many of the hubs have dust caps, or axle spacers on each side, and these can normally be removed. Removing these covers makes the final product look a lot better as you have less hardware sticking out past the hub when the axle bolts are installed. On the Formula hubs, the dust caps fall right out after banging out the little retaining ring in the counterclockwise direction as shown in Figure 72. Some hubs have C-rings, and some hubs have no caps at all.

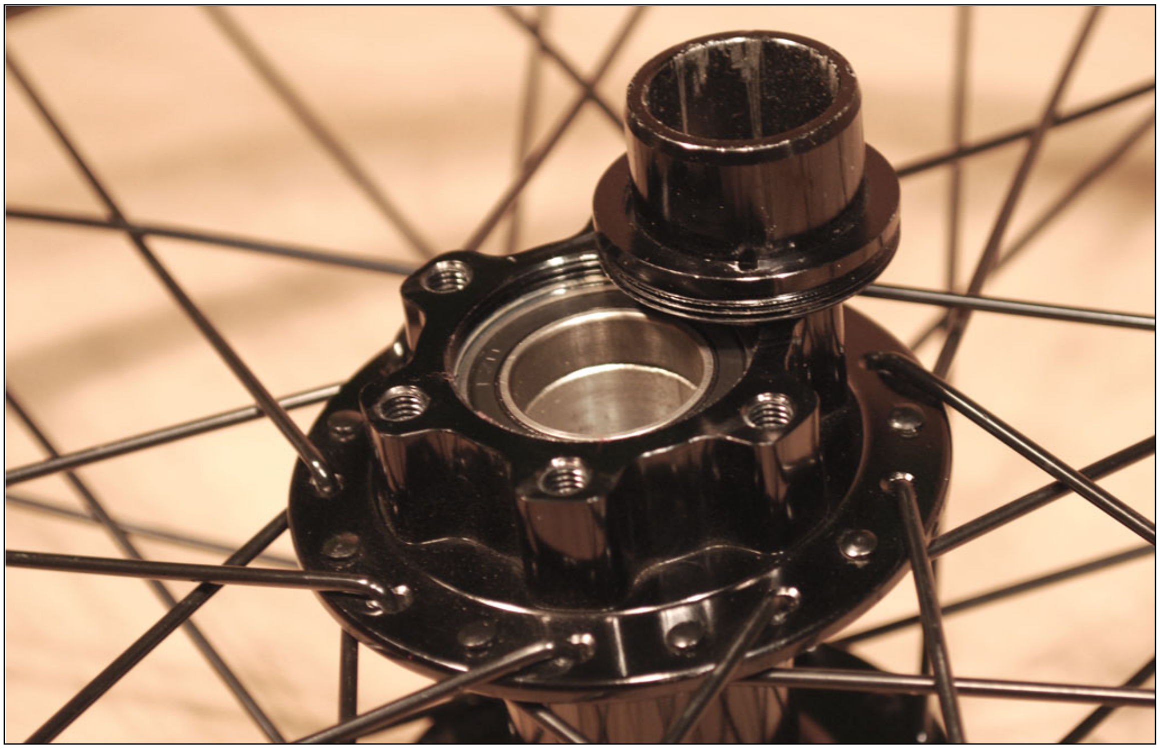

Figure 73 – Close-up of the 20mm ID bearing

The bearing with the 20mm inside diameter is shown in Figure 73, after the removal of the dust caps. The caps do not help keep the bearing inside the hub shell, so they are not needed in the final design. The bearings are resting on a ridge inside the hub, and another small tube is placed between them so that inward pressure does not stress the races. This makes it easy to secure the hub using only a single bolt placed between the bearings.

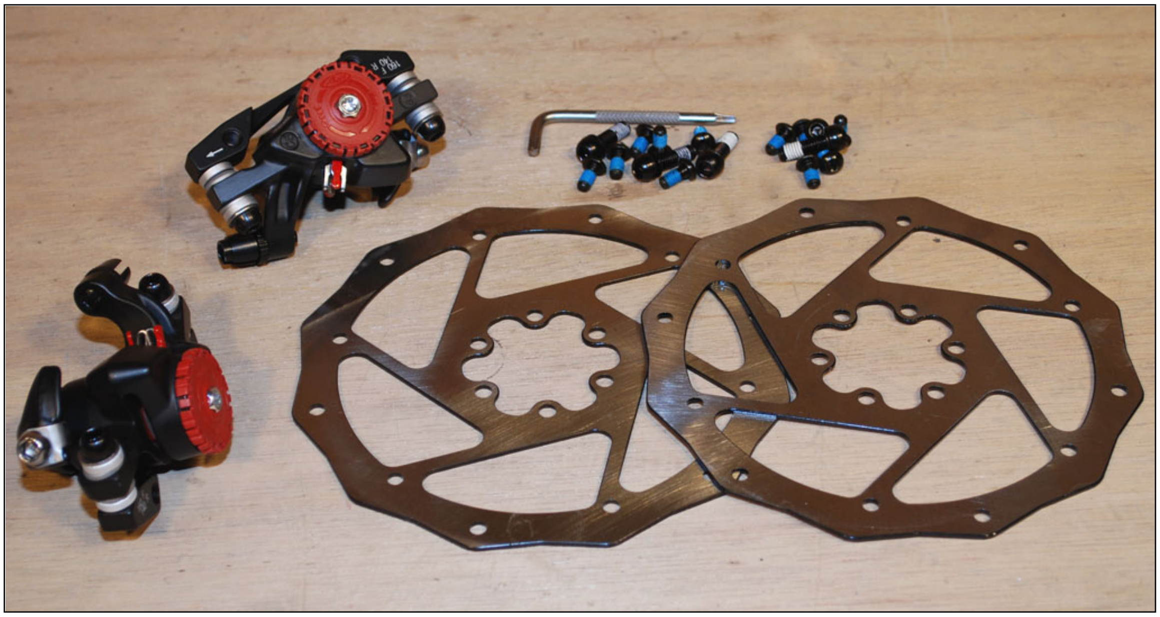

Figure 74 – A set of disc brakes and calipers

The disc brakes for the front wheels need to be the same size and type so that they offer equal stopping power. There are many options available, as well as rotor diameters. I have found that the inexpensive "generic" mechanical types work really well and are very easy to setup. The disc brakes shown in Figure 74 are made by "Avid" and come as a kit for under $50. As for rotor diameter, the smallest size (160mm) is perfect, but you could certainly use a larger rotor if you have them already.

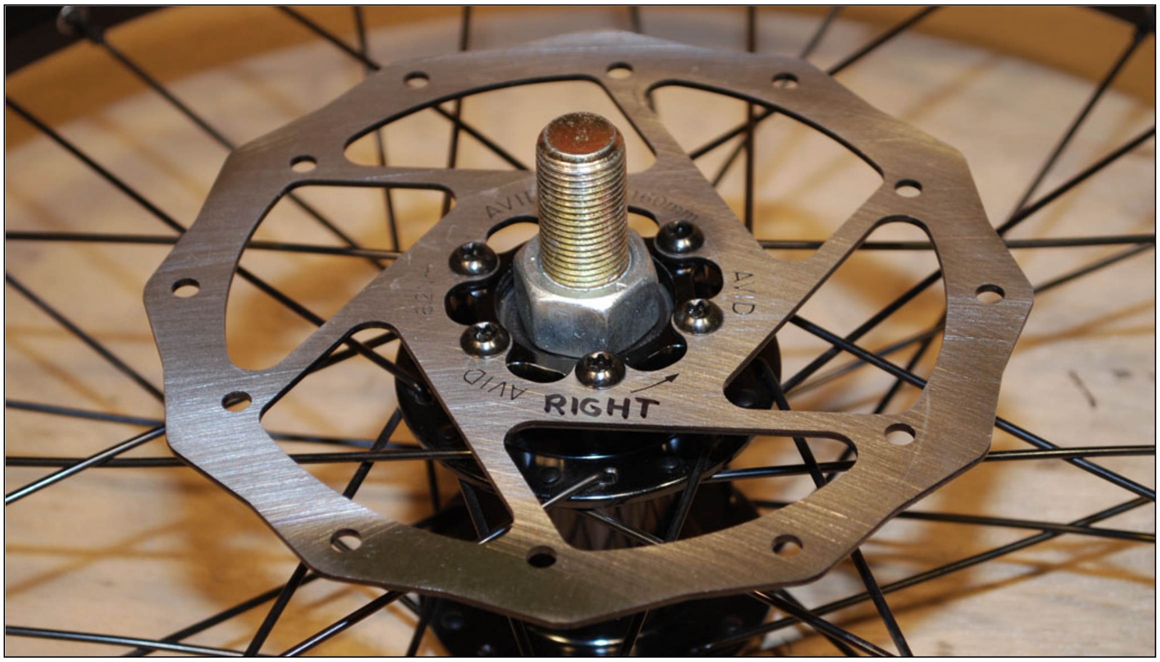

Figure 75 – Disc rotation is important

The disc brake rotor will have an arrow indicating direction of rotation, and it is important that you install them correctly for the right and left wheel. Figure 75 shows the right side rotor installed so that the arrow points in the direction of rotation when moving forward. Also shown in Figure 75 is the 5/8 inch diameter bolt that will secure the hub to the steering hardware.

Make Bolt Spacers

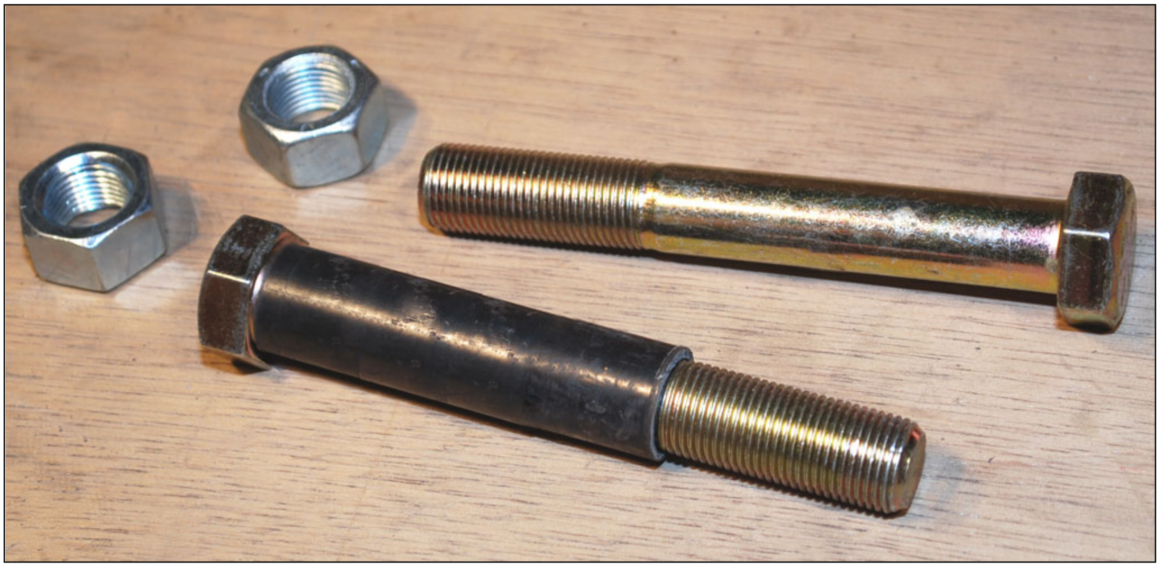

Figure 76 – The bolt spacer option

The bolts needed for the front hubs are 5/8 in diameter and long enough so that the once a bolt has been placed up against the bearing, there is at least 1.5 inches more threaded area sticking out past the bolt. A look ahead at Figure 88 and the half inch thick axle mounting tab will explain why this is necessary. Since hub widths may vary, you will need to have the hubs in your possession before purchasing the correct length of bolts. Besides being 5/8 in diameter, the bolts should be fine thread and have lock 2 lock nuts as well as four regular nuts to go onto them. Two of the regular nuts serve as spacers between the axle tabs and bearings and two of them make life easier until you finish the trike and decide to install the locking nuts.

Obviously the 5/8 bolt is too narrow to fit snugly into the 20mm bearings, so some type of spacer will be needed to fit the bolts into the 20mm bearings of you hub. 20mm bolts are not common, and would be way too heavy, so the spacer option is the way to go. There are two ways you can get the 5/8 bolts up to 20mm – using a machined or “close enough fit" tube like the one shown on the bolt in Figure 76, or by simply building up the surface of the bolts as will be shown next.

If you choose the round tubing spacer option shown in Figure 76, just ensure that the spacer does not stick out past the edge of the bearing or the nut will not tighten up against the bearing. The tube shown being used as a spacer in Figure 76 is not quite 20mm, but was close enough to hold the rims in position. Once the bolts are tight, a little play will not matter, and some paper or thin sheet metal could always be wrapped around the spacer just to shim it up a bit.

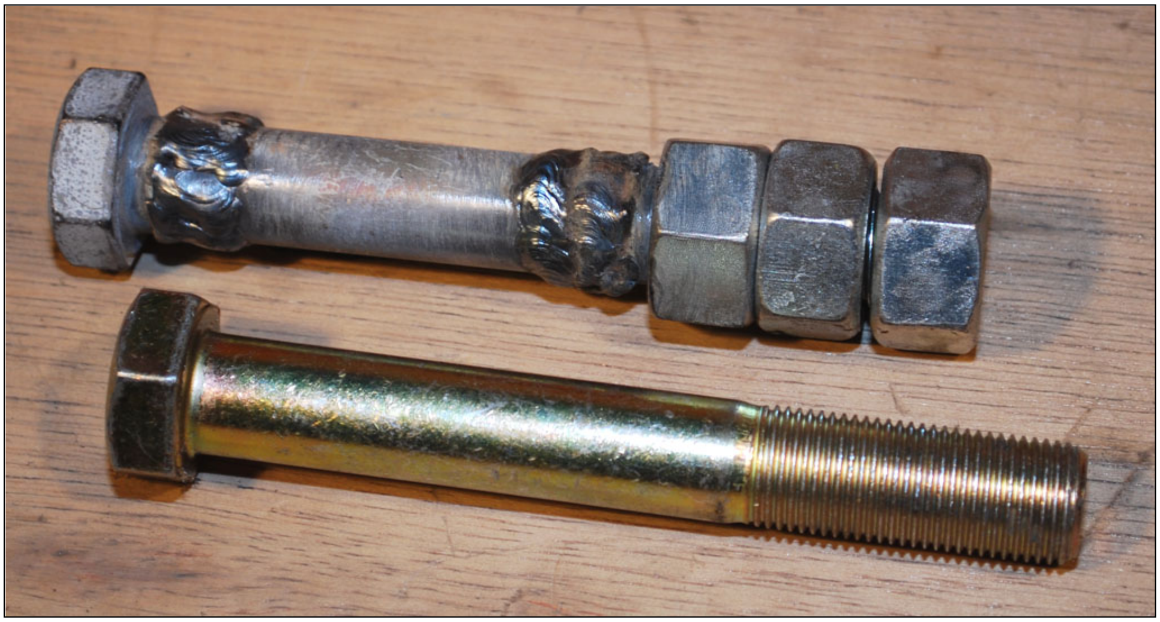

Figure 77 – Building up the bolt diameter

The easier and more "garage hacker" friendly way to make the bolts fit into the 20mm bearings is to simply build up a rim of weld bead, and then work it down with a flap disc to create a raised 20mm surface for the bearings to seat. This system is easy to do, costs nothing, and is lighter than the spacer option.

To begin, place nuts over the threads as shown in Figure 77 to protect the threads from weld spatter and then make beads around the head and base of the bolt until you have at least 20mm or more of a raised surface. Perfection is not important, and your bench grinder or flap disc can easily work the surface down to a more rounded 20mm diameter.

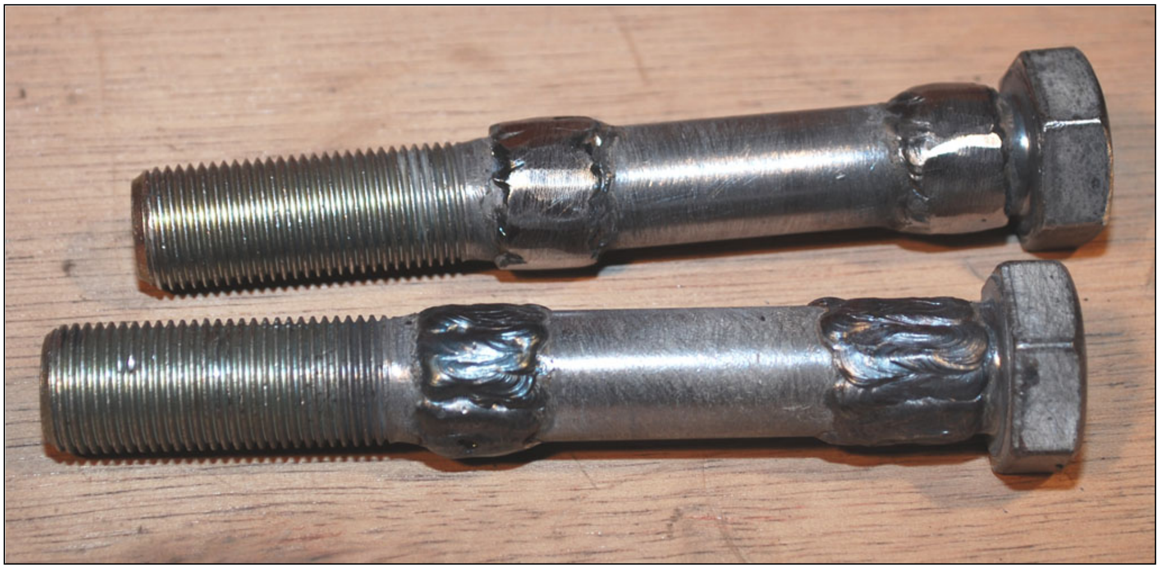

Figure 78 – Grinding the new surface round

I only have a hand held grinder, but by using a flap disc to fix up the raised surface (top of Figure 78), the bolts now fit nicely into the bearings with almost no play. The bolt shown at the bottom of Figure 78 has not been ground yet, so the surface is a bit larger than 20mm, and contains 3 passes of weld bead to get to that height. Simple hacks like this can save you a lot of money on machine work, and allow the creation of just about anything. If you have a lathe, then you could make these bolts perfect, and even take out some of the center material to make them lighter. Machining the center of the bolts to half an inch would be just fine.

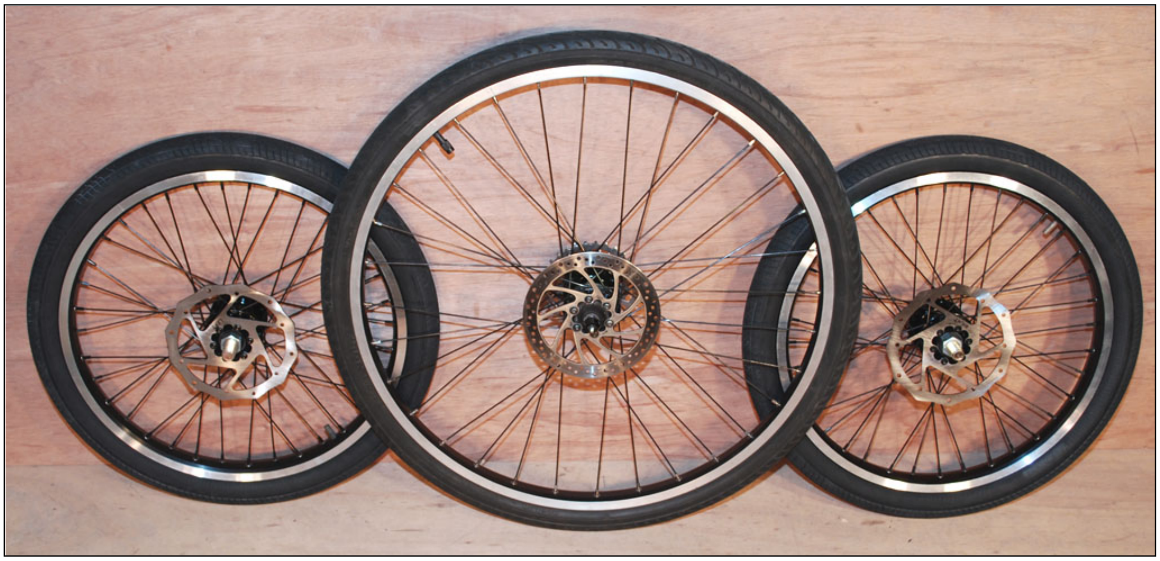

Figure 79 – Front and rear wheels with discs and bolts

The three matching wheels are shown in Figure 79 after installing the brake rotors in the proper direction as well as the newly “hacked” 20mm raised axle bolts. All tires are rated for 75 PSI or better and have minimal tread so that rolling resistance will be very low. Aggressive treads on bicycle tires is nothing but a waste of energy and will greatly reduce your ride quality. The Warrior uses 20 inch rims on the front and a 26 inch rim on the rear.

Make Axle Mounting Tabs

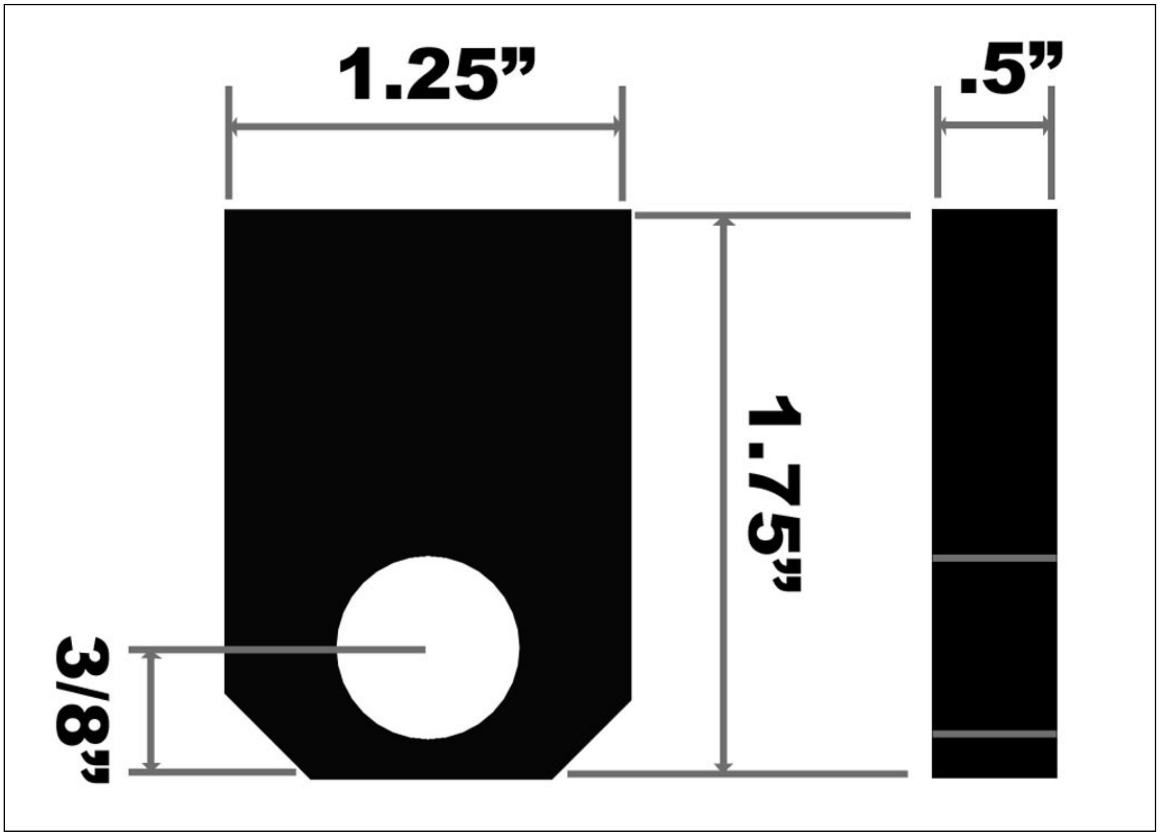

Diagram 4 – Axle mounting tab dimensions

The bolts that have been fixed to hold the hubs will have to connect to the steering hardware somehow, so a set of axle mounting tabs will be made from some scrap steel plate. The dimensions of the axle mounting tabs are shown in Diagram 4, and can be made from either half inch plate, or by welding two ¼ inch pieced together. I don’t have much heavy steel in my shop, so the dual plate method is what I always use. The tabs could be as thin as 3/8 as well, but don’t go any less than that.

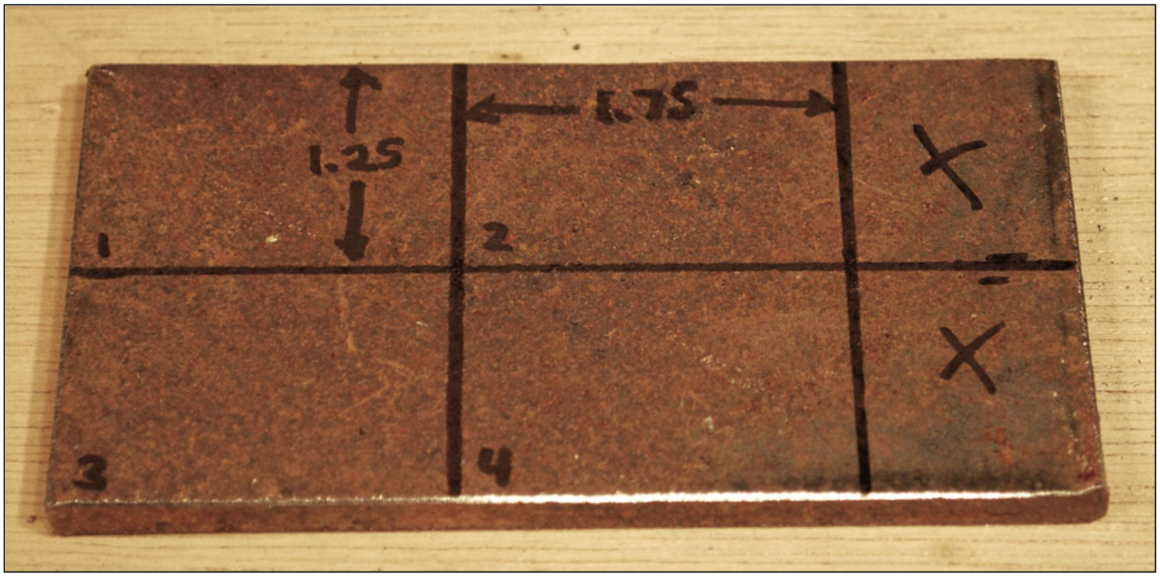

Figure 80 – Cutting 4 pieces to make the 2 axle tabs

The scrap ¼ inch thick steel shown in Figure 80 will be cut as per Diagram 4 in order to make the 2 axle mounting tabs.

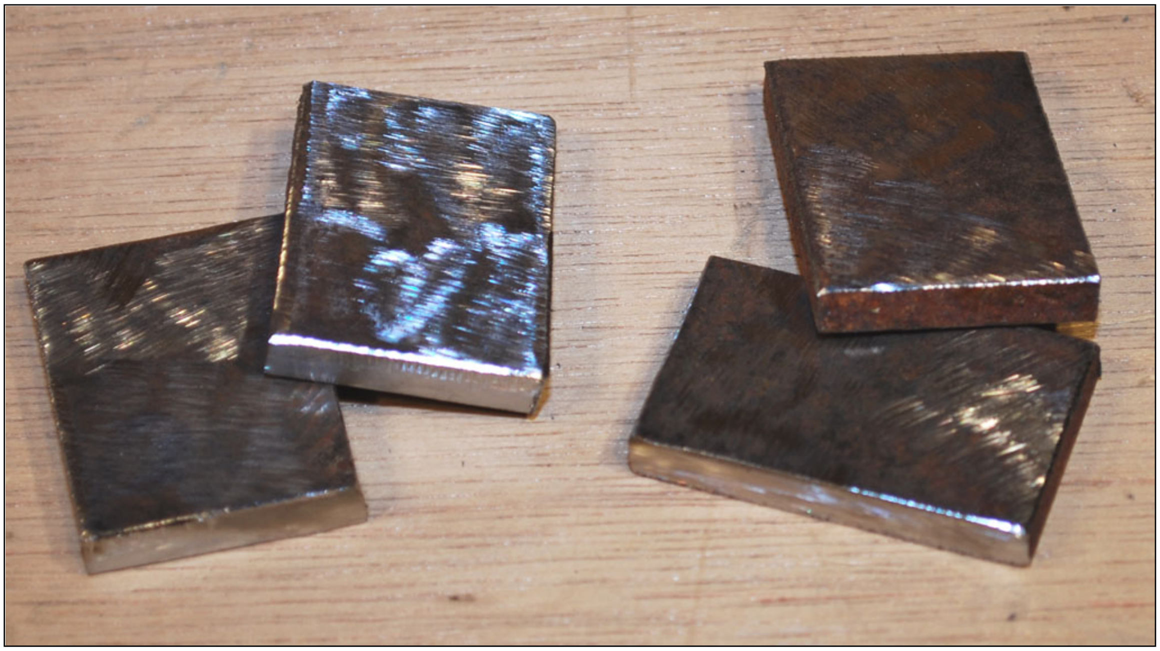

Figure 81 – These parts will be joined together

The four pieces shown in Figure 81 will be welded on the edges to make a pair of axle mounting tabs half an inch thick. All of my cutting is done with a 3/32 zip disc on a hand held angle grinder as this would take a while with a hacksaw!

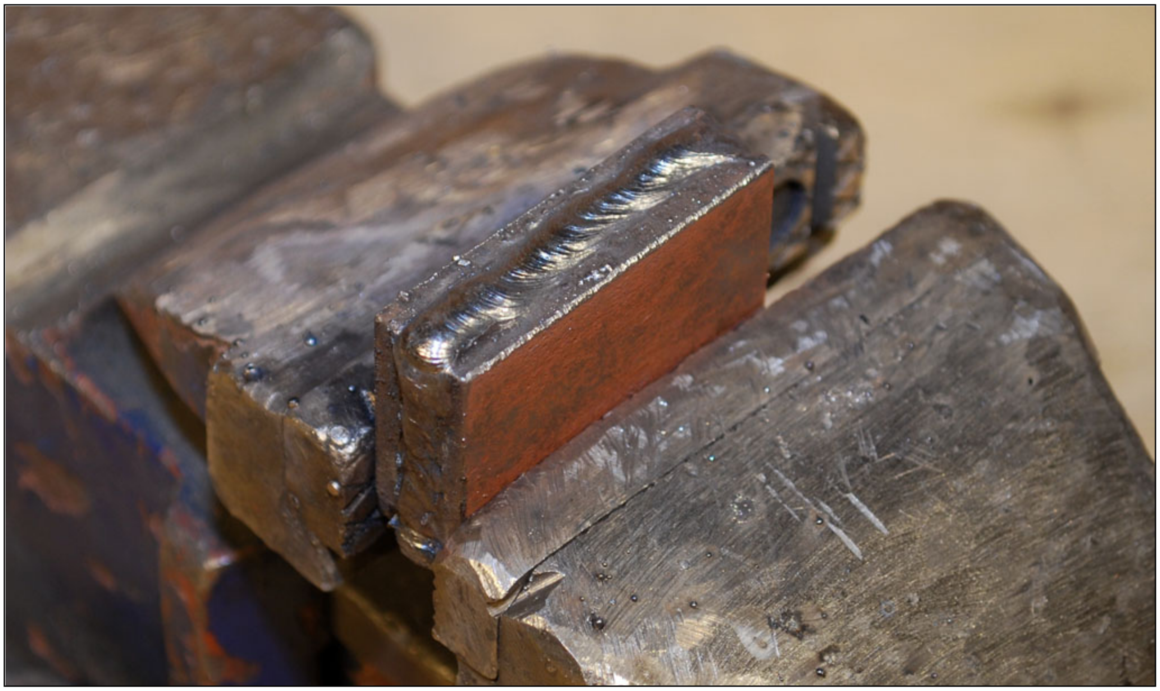

Figure 82 – Welding a pair of tabs together

To create the required thickness for the axle tabs, two smaller pieces are welded around the edge as shown in Figure 82 in order to make one piece. Don’t worry too much about military precision here as the parts will be ground later to round them off and equalize them all.

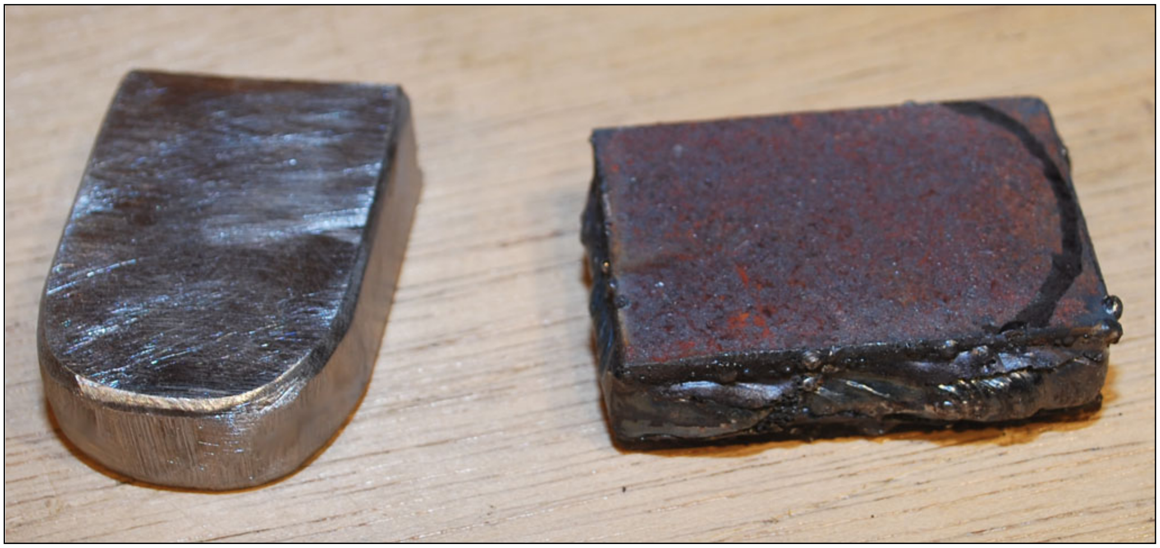

Figure 83 – One axle tab ground clean

The ugly weld sandwich shown on the right of Figure 83 will become the nicely rounded axle tab shown on the left after a little work with a heavy grinder disc and then a flap disc.

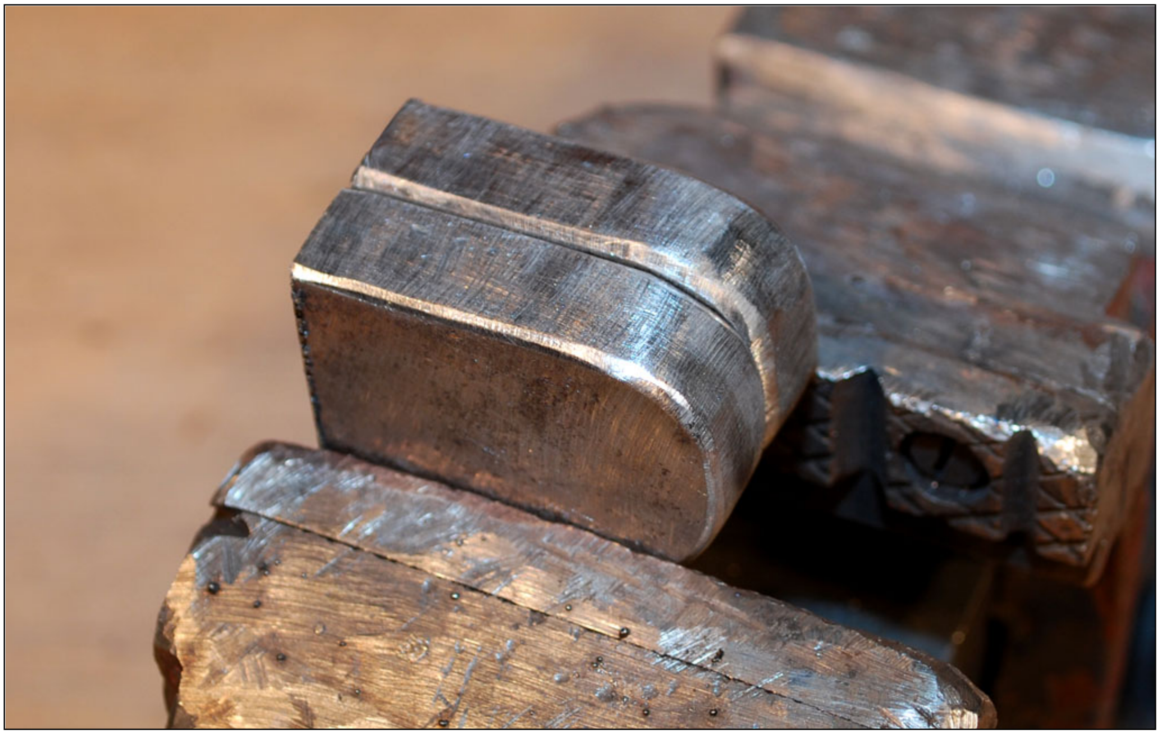

Figure 84 – Making both parts equal size

To ensure that both completed axle mounting tabs are exactly the same size, place them in the vice side-by-side and make any needed adjustments. Figure 84 shows the result of grinding and cleaning up both parts with the heavy disc and then the flap disc.

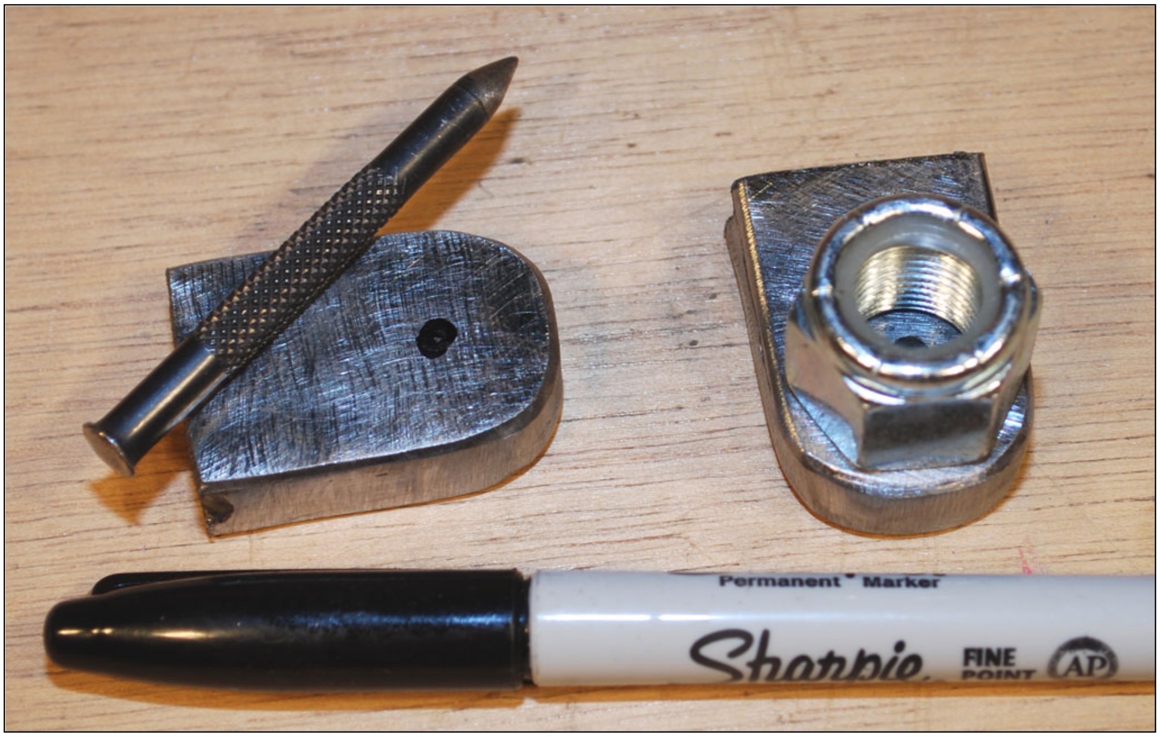

Figure 85 – Finding the bolt hole centers

To find the optimal place to drill the bolt holes, place on of the nuts on the end of the tab so it is as close to the edge as possible and then use a marker to mark the center point. A punch is then used to create the place where you will start drilling. Another method is to use a paper guide so you know that the bolt holes will be in the same place on both tabs. Figure 85 shows the marker method being used to mark the bolt hole centers.

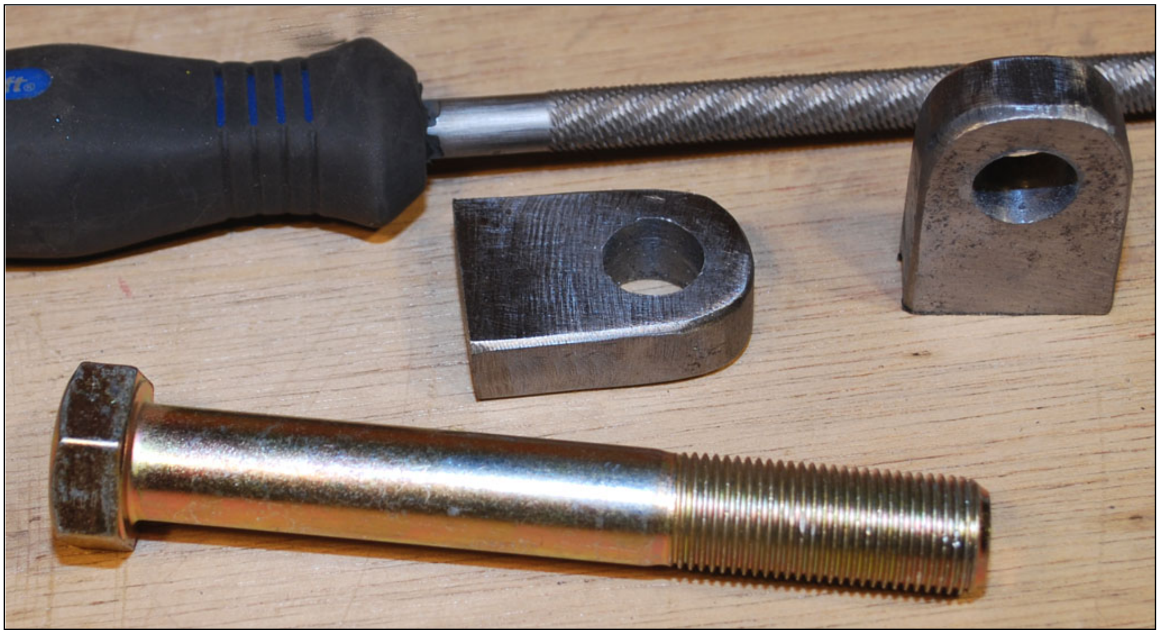

Figure 86 – Drilling out the 5/8 bolt holes

Since I only own a hand drill, I can only drill a hole as large as half an inch before I have to resort to the hand file. To drill the hole accurately, I start with a 1/8 bit and then work through the entire drill bit set until I am at the largest bit or the required size. A step drill and drill press would be more accurate, but I have always found a hand drill to work well enough. Figure 86 shows the bolt holes drilled to half an inch – the maximum size my drill bit can do.

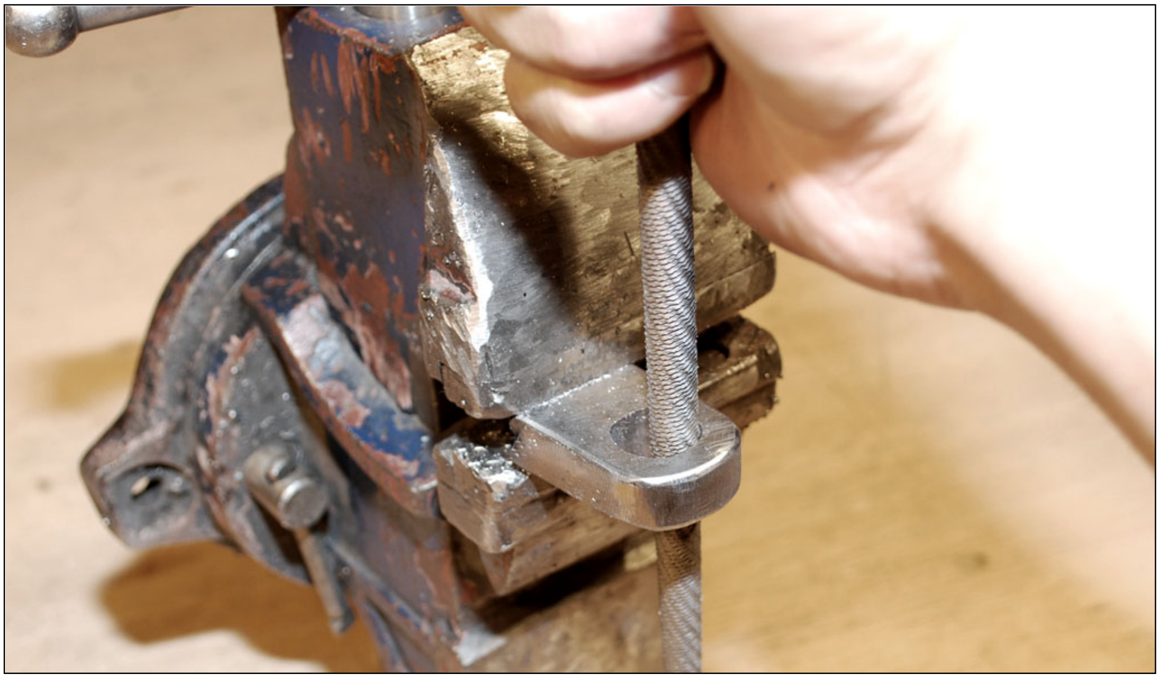

Figure 87 – A good way to exercise you arms

To get the extra 1/8 inch of diameter, I use a round file as shown in Figure 87 to complete the holes. This hand filing also allows a last chance to align the holes a bit better if both don’t line up perfectly. I have never bolted down my vice, and find it so much more useful for jobs like this.

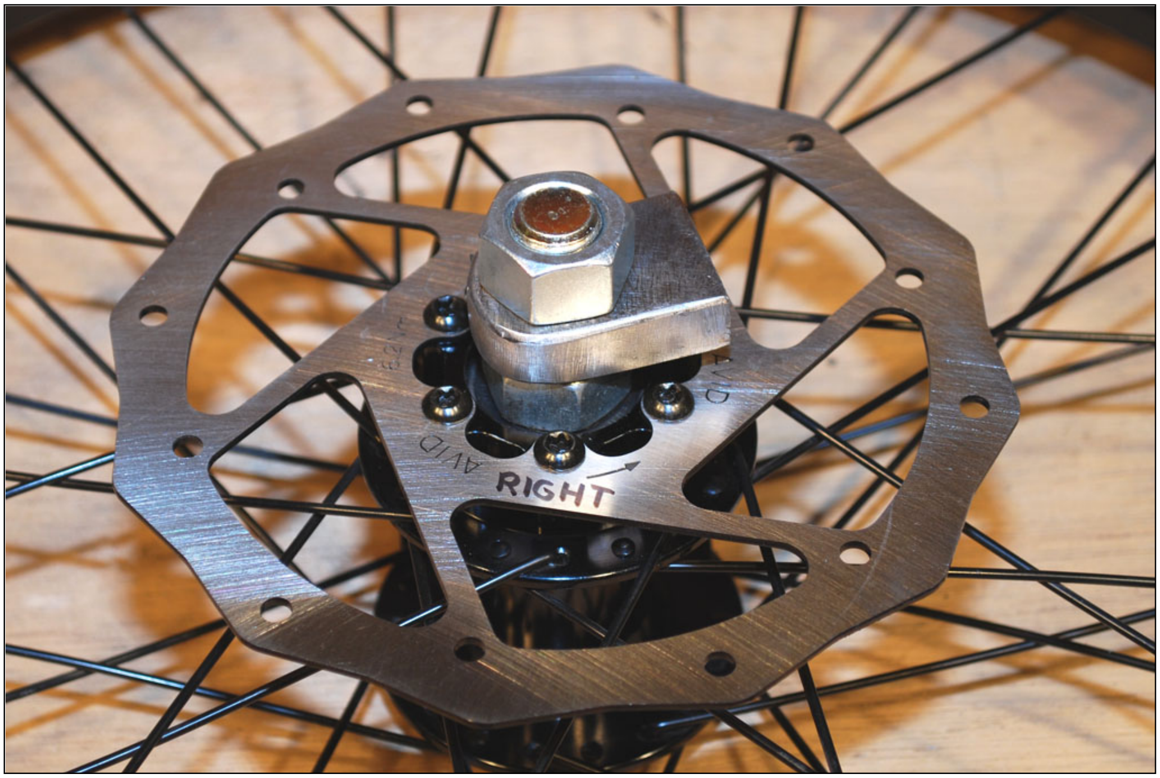

Figure 88 – Installing the axle tabs

After 20 minutes of hand filing, the axle tabs fit perfectly onto the axle bolts as shown in Figure 88. At this point, I am not using a lock nut, because it would become very annoying to have to take it on and off while building the trike. Locking nuts are certainly recommended, though, when you put the axles on for the last time.

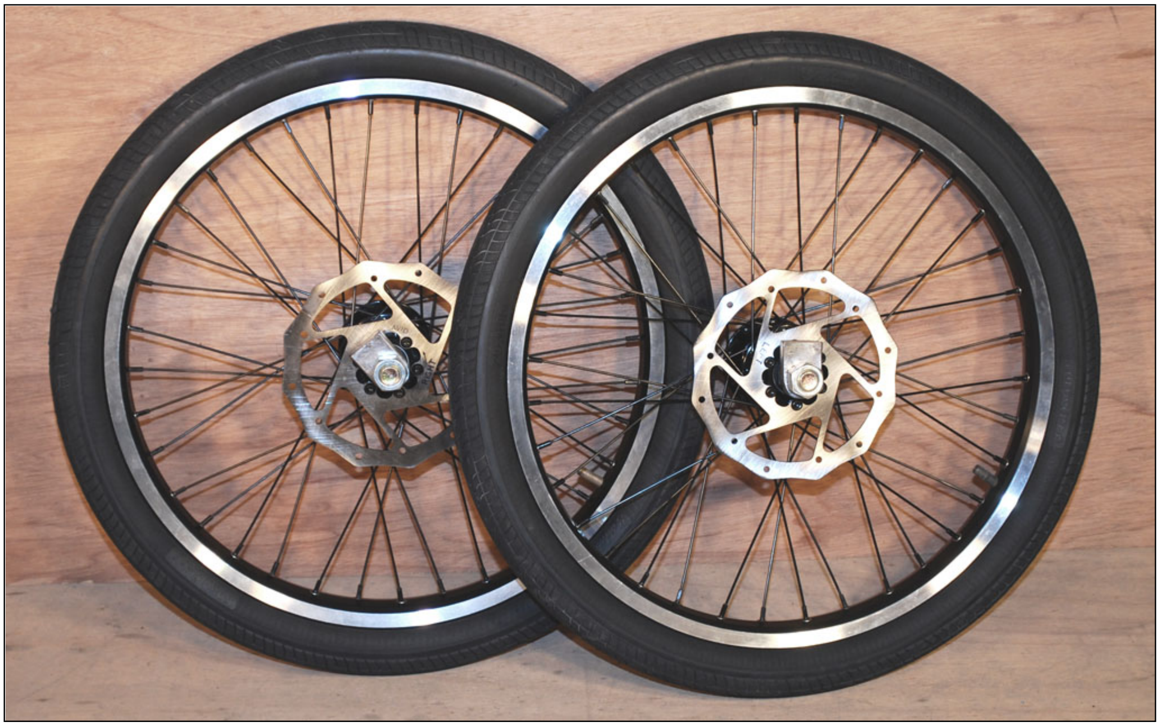

Figure 89 – Completed axle tabs and wheels

The completed axle tabs are shown secured to the 20 inch front wheels in Figure 89. The creation of the steering hardware will follow.

Make the Steering System

Head Tubes

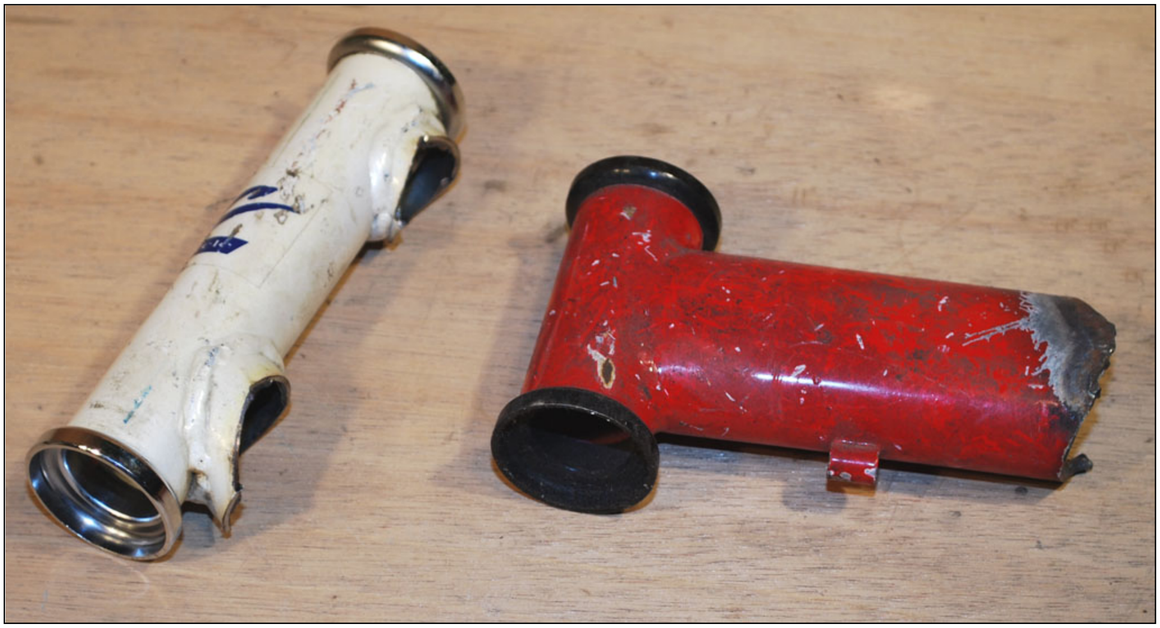

Figure 90 – Head tubes salvaged from bicycle frames

Bicycle head tubes are lightweight, easy to weld, and are designed to allow frictionless steering on a bicycle, so we will use them for our steering hardware. Some trikes use brass bushings and a bolt to allow the wheels to turn, but that system becomes heavier and tends to either feel stiff while turning or can rattle due to being sloppy. Since a bicycle head tube already works perfectly, it only makes sense to use them. You will need a pair of head tubes and hardware like the ones shown in Figure 90.

Since the Warrior's head tubes are only 2.5 inches tall, it really does not matter if the two donor head tubes match in length, as long as they have the same diameter. Actually, that does not matter either, but would certainly look better in the end. If you can dig up a head tube that is at least 5 inches tall, then you only need one, as it can simply be cut in half to yield a pair of 2.5 inch tall head tubes.

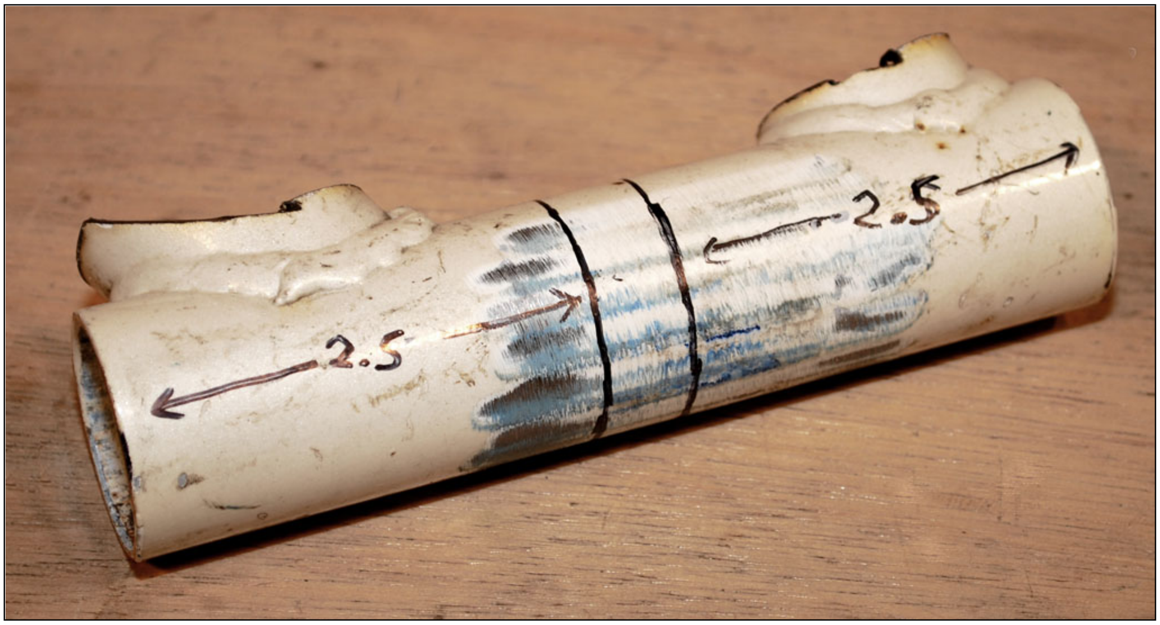

Figure 91 – Turning one head tube into two

The head tube shown in Figure 91 was 6 inches tall, so there was enough material to make the two require 1.5 inch long head tubes. When cutting a head tube down, use a bit of tape or paper to help make the cut line around the head tube.

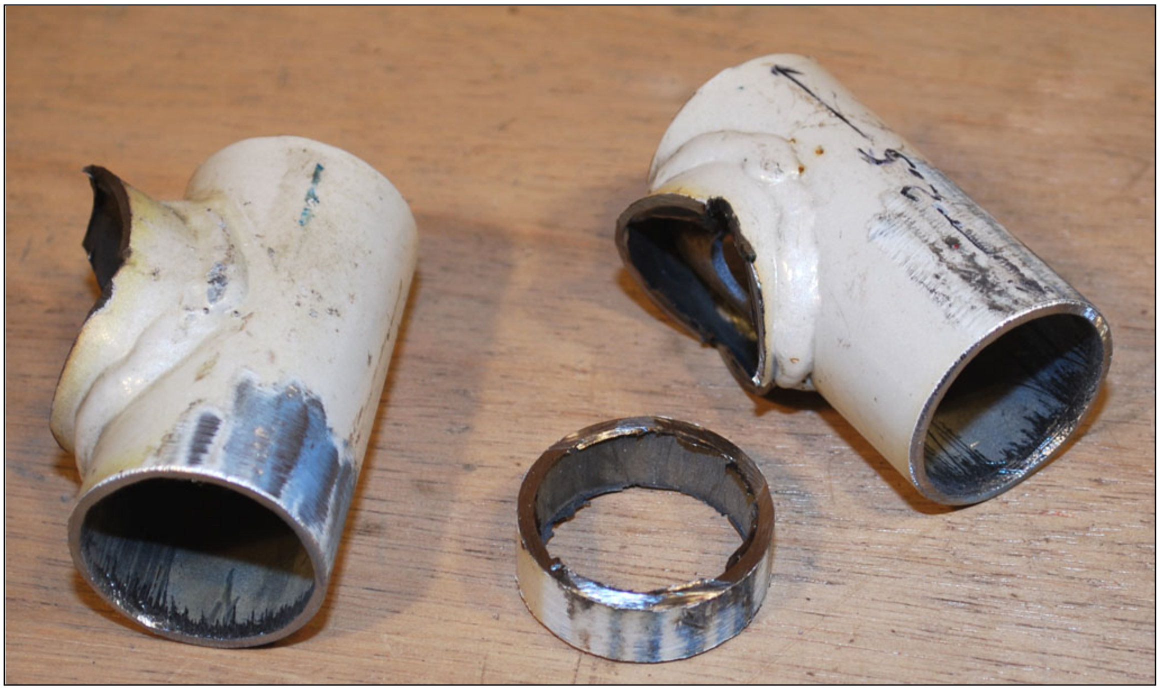

Figure 92 – Two head tubes with a bit to spare

In the end, you want two equal diameter (recommended) and equal length (required) head tubes as shown in Figure 92. You could get away with a little taller than 2.5 inches, but should not make them any less than that. Also notice in Figure 92 the cut ends of the head tubes have been worked around the inside edge a bit with a round file to help the fit the bearing hardware back into the tube. Just a little taper is all that is needed to tap the rings back in place.

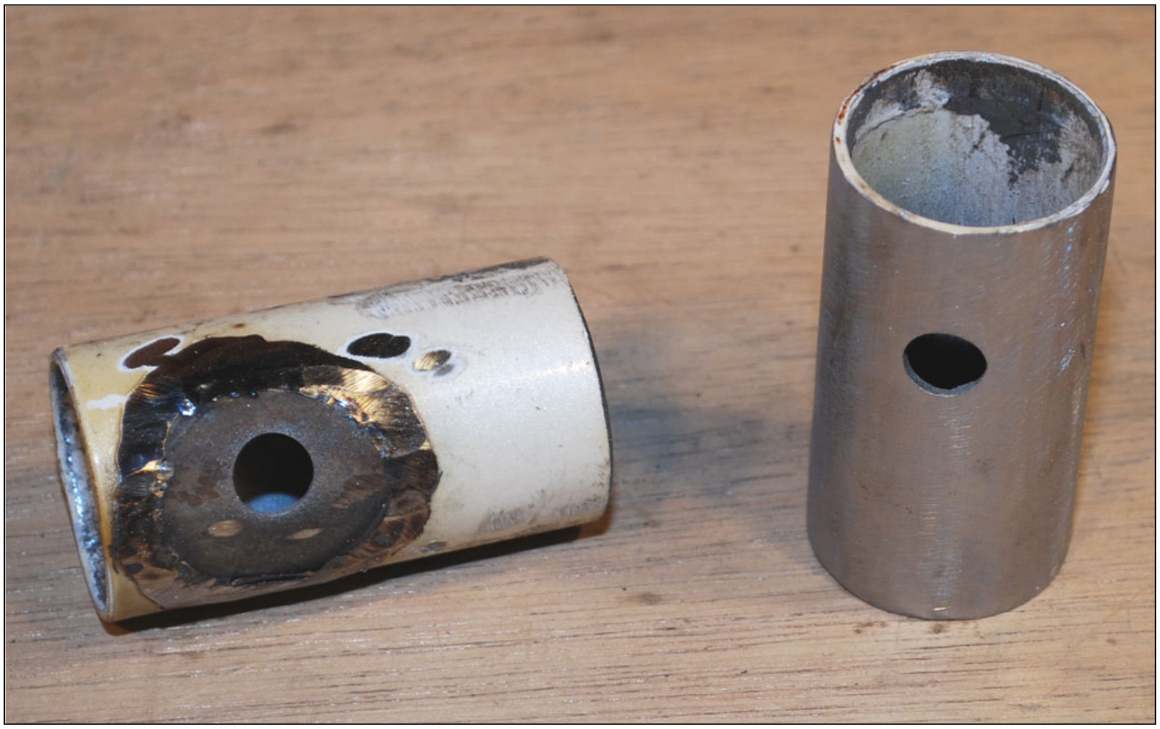

Figure 93 – Cleaning up the head tube shells

To clean up the access tubing from the head tube shells, start with the rough grinder disc and then clean up the last bit of material and paint with the flap disc. The resulting head tube (Figure 93) will look as good as new. Don’t worry about filling the small holes as they will be covered by the frame tubing.

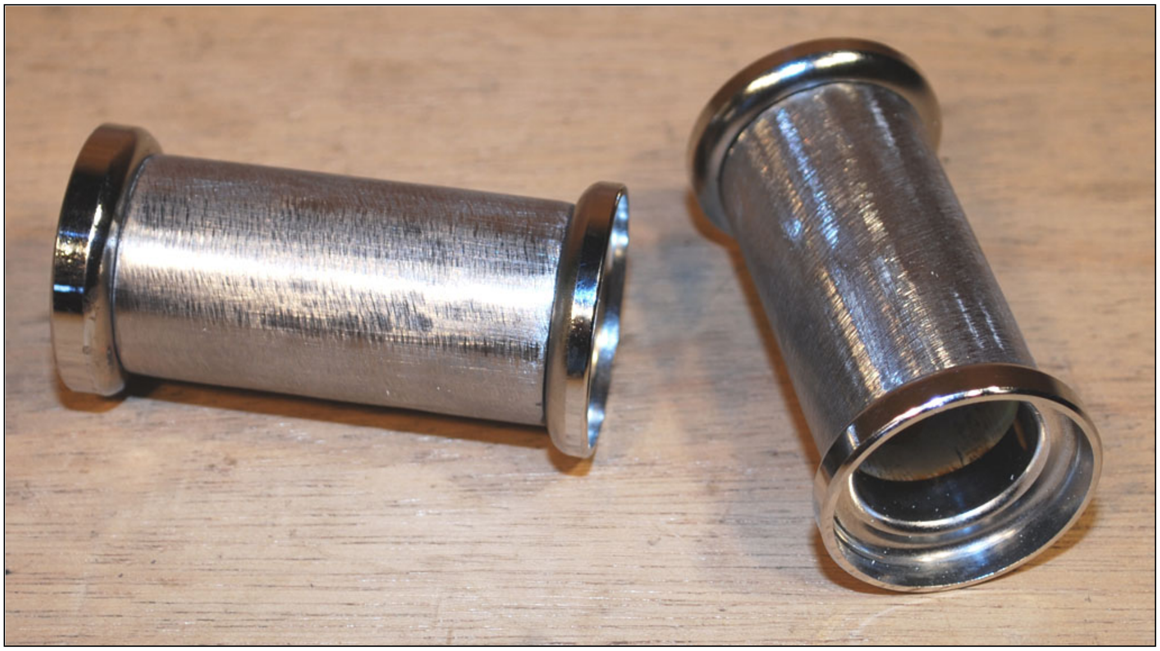

Figure 94 – Finding a matching cup set

If you have been collecting piles of scrap bike parts, then do some digging and try to find a matching set of head tube cups as it symmetry is always nice to have on a finished trike. I found these retro chrome cups (Figure 94) in my bucket of random head tubes, and they matched perfectly.

Fork Stems

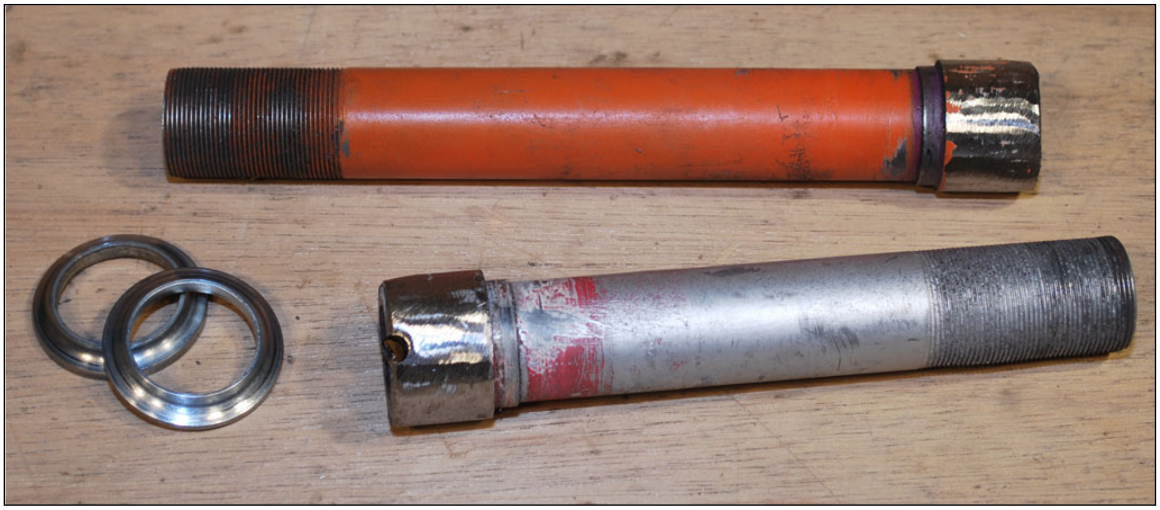

Figure 95 – Fork stems with legs removed

You will need to find a pair of fork stems to create the hardware to fit into the head tube. As shown in Figure 95, the length of the stems is not important since both will have to be cut and re-welded to fit the 2.5 inch tall head tubes. After you trim the fork legs from the crown area, trim the crowns down to 1 inch so they are both the same size. The bearing races (shown removed in Figure 95) can just be tapped on or off with a chipping hammer or chisel.

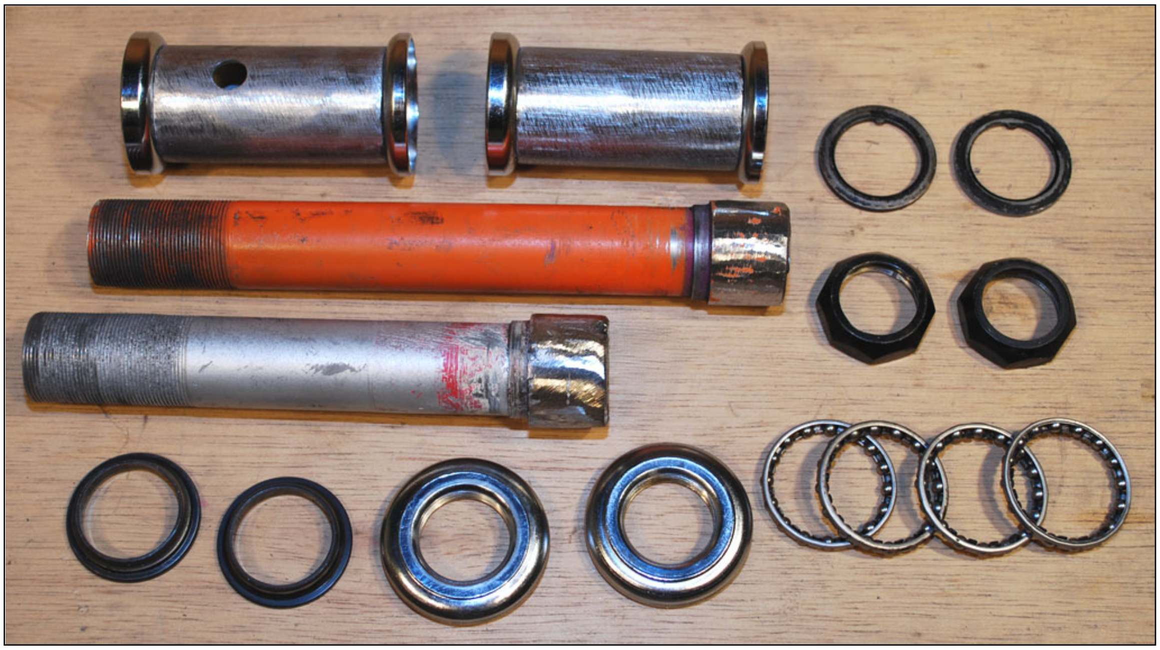

Figure 96 – Colleting all of the fork hardware

Besides the head tubes and fork stems, you will also need the matching hardware, which includes the bearings, top races, and lock nuts as shown in Figure 96. If you can, try to find matching sets.

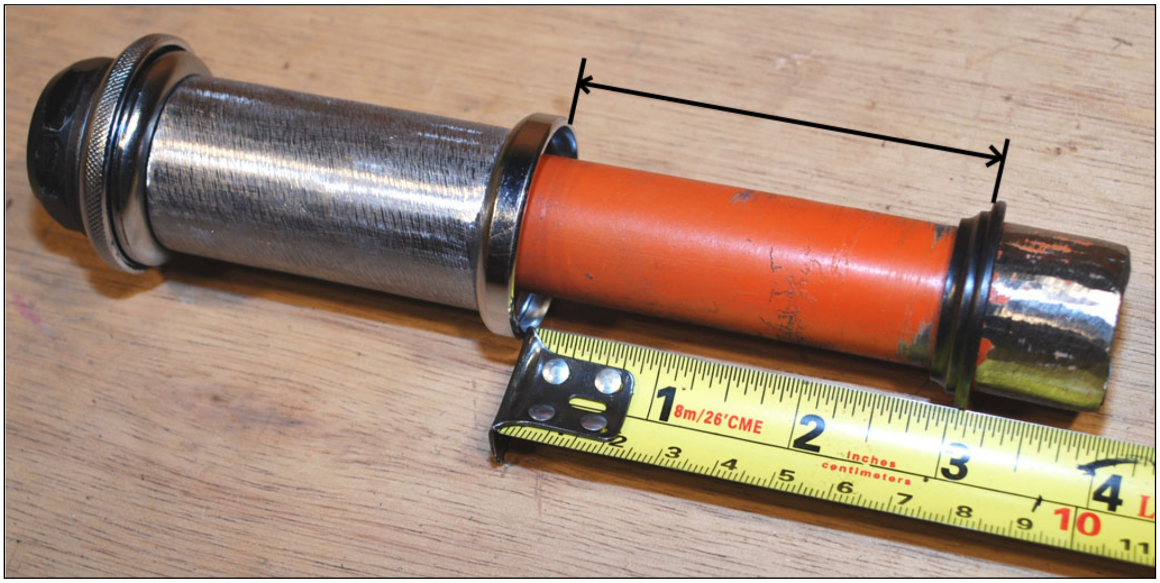

Figure 97 – Determining how much to trim

To calculate how much of the fork stem length has to be trimmed, just install the top hardware (including the bearing), then measure the distance from the bottom cup (the larger cup) to the top of the large ridge on the fork stem race. As shown in Figure 97, I have to trim just over 3 inches from this stem.

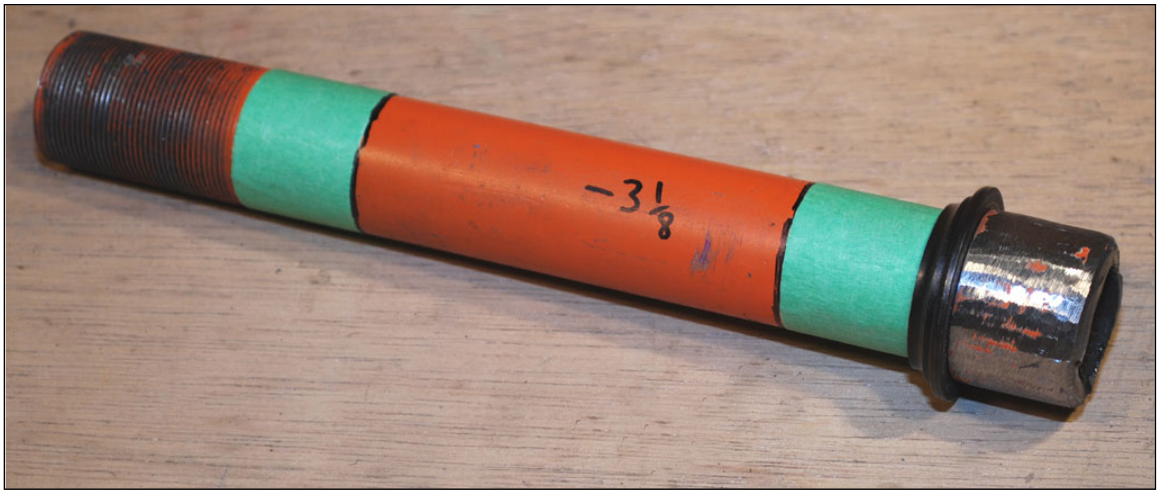

Figure 98 – Marking the area to be cut

The area to be trimmed should be in the center of the stem so you are not welding on the threads or too close to the lower race. A bit of tape around the tube as shown in Figure 98 helps to create a good cut line if you don't have a pipe cutter to use.

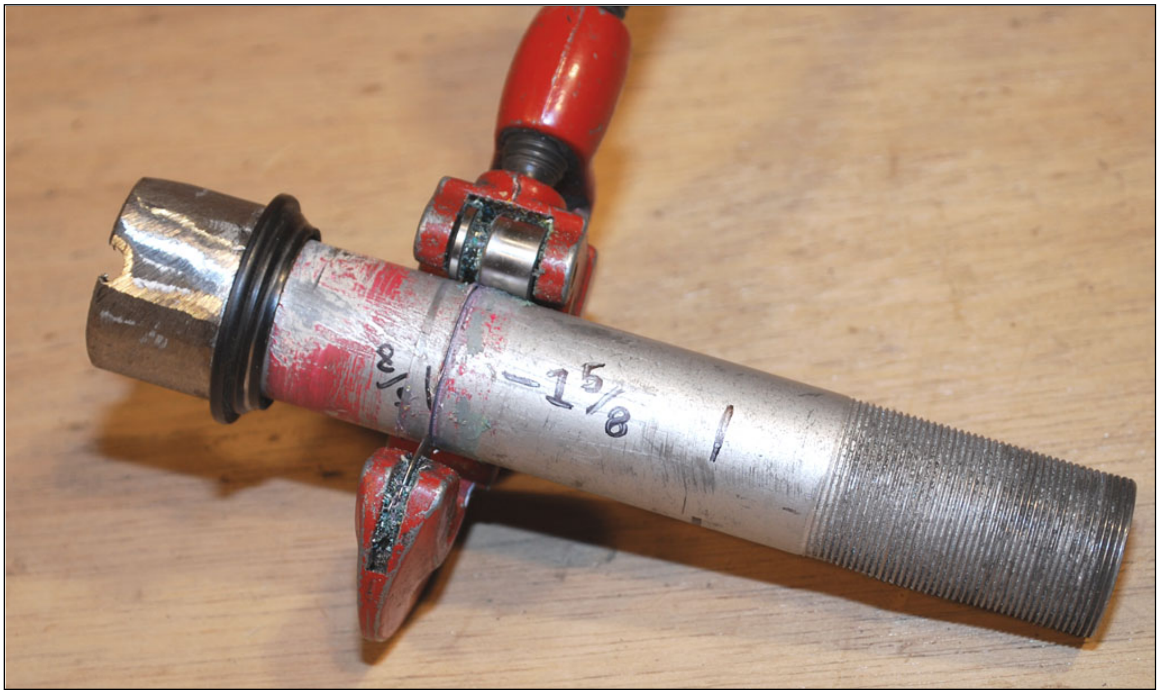

Figure 99 – A pipe cutter is best for this job

For a few dollars, you can purchase a small pipe cutter that will cut tubing up to an inch in diameter perfectly. As shown in Figure 99, the tool is clamped to the tube and turned in circles until it makes a perfect cut.

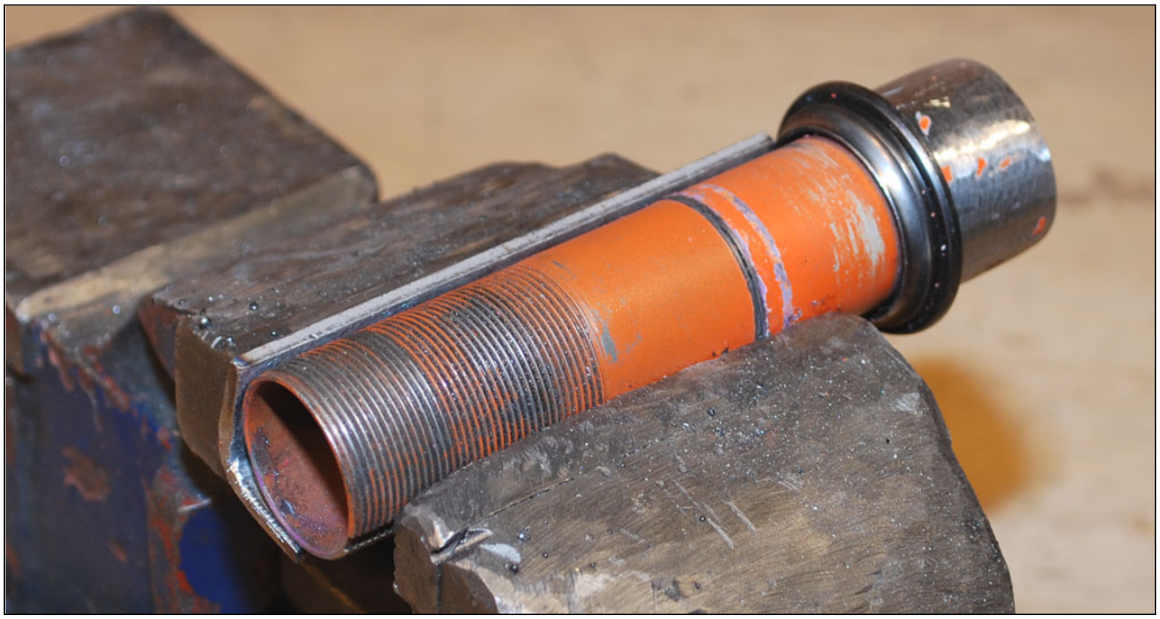

Figure 100 – Aligning the tubes for welding

To rejoin the fork stem sections, place them in a vice along with a bit of angle iron so that they are held perfectly inline as shown in Figure 100. Tack weld a few places and then remove the fork stem to check alignment before welding all the way around the joint.

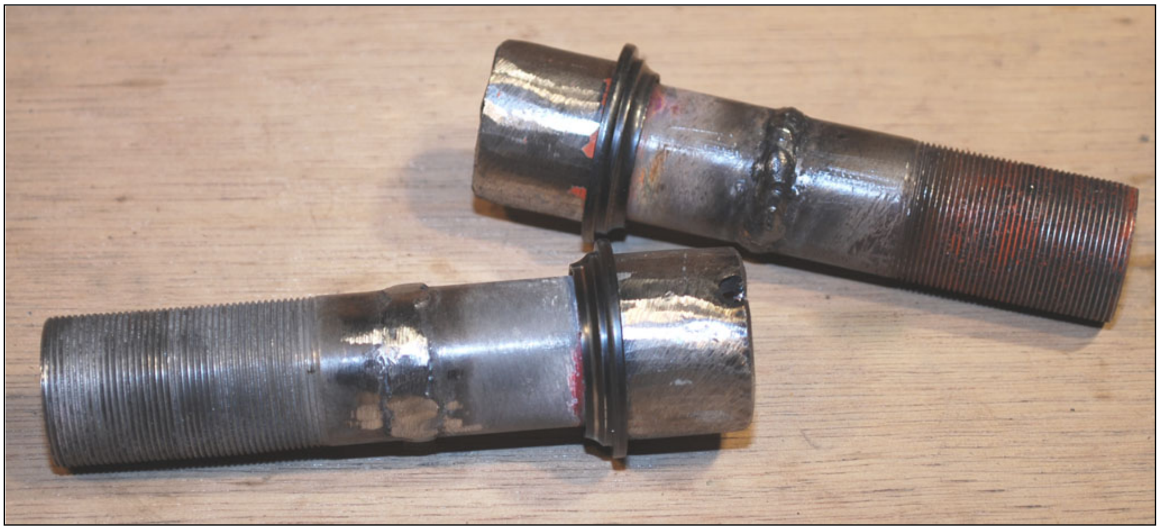

Figure 101 – Cleaning the welded fork stems

After welding all the way around the fork stems, you likely need to take off a bit of the weld metal in order to get the stem to fit into the bearing cups. Only flatten the weld as much as you need (Figure 101 bottom) so that you don't weaken the joint.

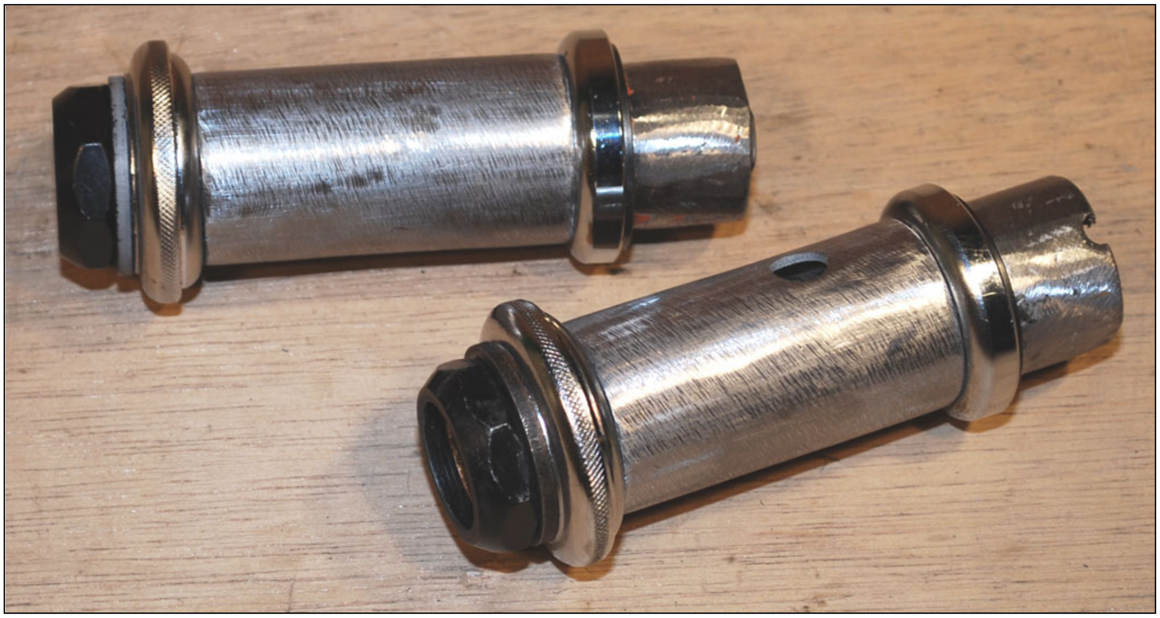

Figure 102 – Two mini head tubes and hardware

The completed and reassembled mini head tubes shown in Figure 102 fit together perfectly and spin with almost no friction. If your steering parts seem stiff then most likely you have the bearings installed the wrong way or the cups are the wrong size for the bearings or races. There are at least 3 small variations in bearing and cup sizes, so taking all of the parts from the same source is always helpful.

Determine Wheel and Steering Alignment

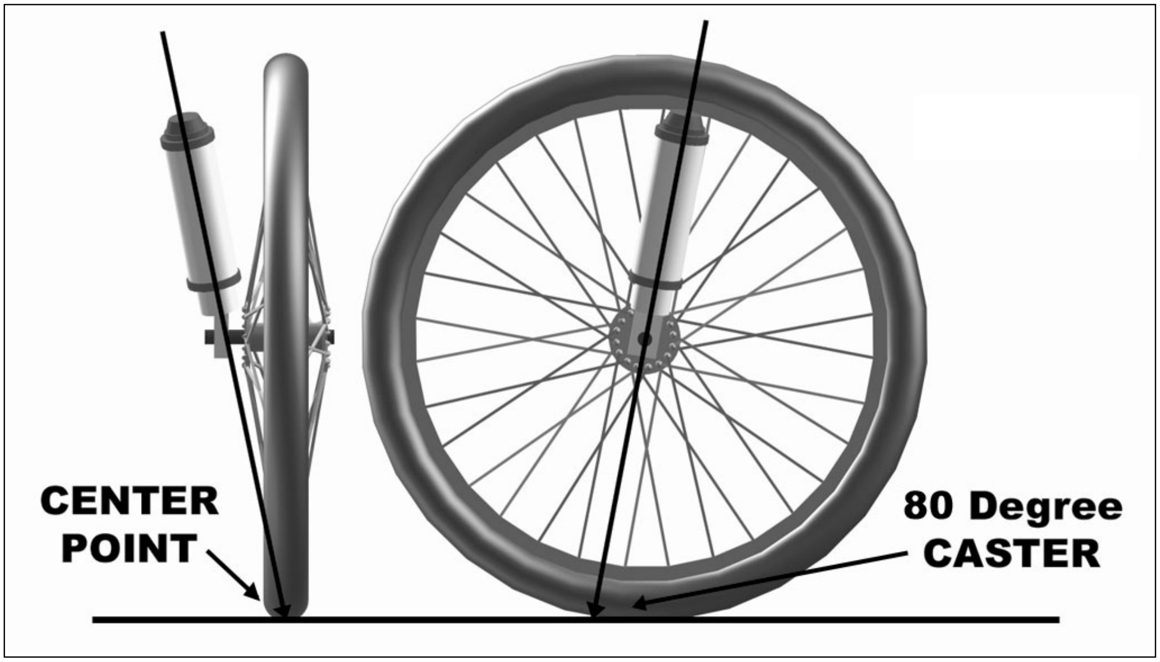

Diagram 5 – Head tube angles of concern

The most angle intensive part of building a tadpole trike is always the alignment of the front wheels and steering components. There are quite a few angles to deal with, and they have to mirror each other on each side of the trike. Although I have done my best to make the plan automatically solve as many angles as possible, there will still be some precision work to do here, so be patient and expect to make a few attempts at getting certain angles correct. There is a learning curve to all of this, so don’t worry if you have to re-read this section over and over again, and fiddle with angles to get them right, especially if you have made modifications to the original plan.

As shown in Diagram 5, you need to position both head tubes on such an angle that the wheels are standing at a 90 degree angle to the ground, and so that the head tubes are angled slightly forward, creating the desired 80 degree caster angle with the ground. The 80 degree caster angle allows the wheels to self center, creating a more stable ride at high speed with a good degree of response as well as the ability to ride hands free.

If you relax the caster angle too much, your wheels will tend to flop from side-to-side and you will increase your turning circle by reducing the amount of steer. If you make the head tube angle too steep, then your steering will be instantly responsive and somewhat "twitchy", especially at higher speeds, where you will tend to wobble back and forth as you pedal hard. I have found that 80 degrees seems to be a good angle for a trike of this wheelbase, but feel free to alter this angle if you feel that you know what you are doing and how it will change the handling characteristics.

Determine Center Point

Also shown on the right side of Diagram 5 is something called “center point”, which is discussed next.

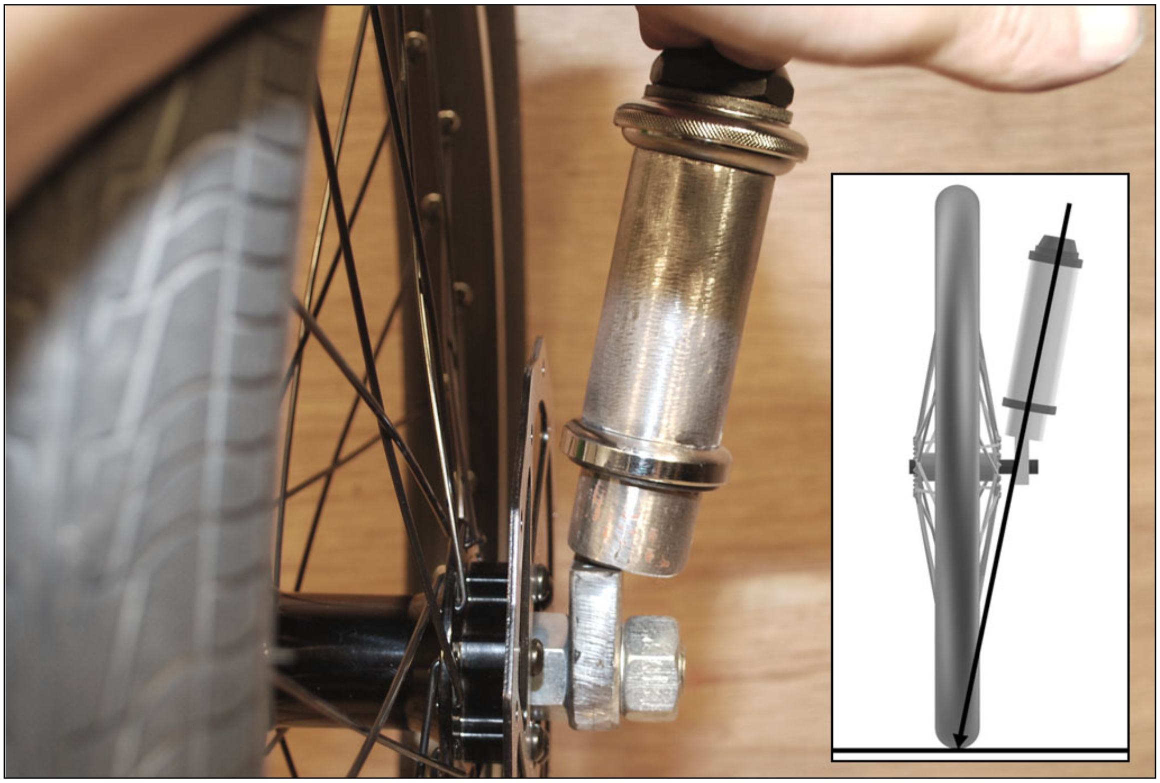

Figure 103 – How center point steering works

Center point steering allows the wheel to pivot on its center where it hits the road. As you can see in the small Diagram in Figure 103, the axis of steering extends through the center of the head tube directly to the exact place where the tire hits the road. Without center point steering, your trike would flop from side-to-side as you made turns, and would feel like it is trying to throw you from the seat at high speed. Another consequence of not having center point steering is that every bump or uneven braking force would try to steer the trike, causing a very dangerous and unpredictable ride at high speed.

The good news is that the center point angle is not hard to find, and it then creates the required angle for each side boom tube automatically. You will have to use your keen eye to align the center point angle at fist though, and then make adjustments using a straight rod later. Figure 103 shows how the fork crown will meet the top of the axle tab in order to create the proper center point angles. The actual angle is a product of your head tube size as well as your hub width and tire size, so setting it up by eye is the only way to get it right for your trike. The tab is placed nearest the inner side of the crown so that the fork hardware does not rub on the disc brake.

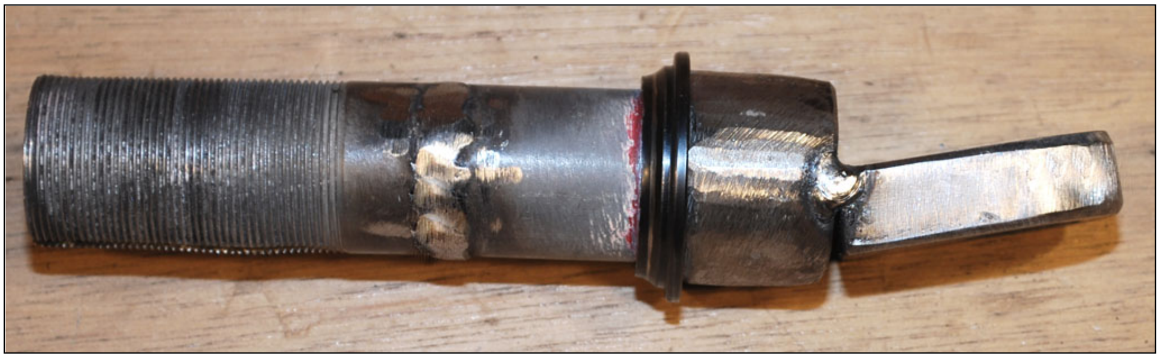

Figure 104 – Making the first two tack welds

Take your best shot at getting the center point angle correct by placing the axle tab close to the inside of the crown, and then make a good tack weld on each side. To make this guess, I hold the parts up with the wheel as shown in Figure 103, then try to memorize the angle that looks correct. Don’t worry if it’s not that accurate, as the tack welds will work like a hinge so you can “bend” the parts into the correct angle. Also, only do this to one of the parts for now since the other side will be copied from this one when it is correct.

With the axle tab tack welded as shown in Figure 104, place it back on the wheel and then use whatever tricks you have to in order to set up the center point angle so that it looks like the Diagram shown in Figure 103. Looking at the edge of the wheel with a straight rod for a guide works as well as holding the fork stem vertically and letting a string with a weight hang down to the tire. I just do this by eye now, and have found that if it looks right, it likely is.

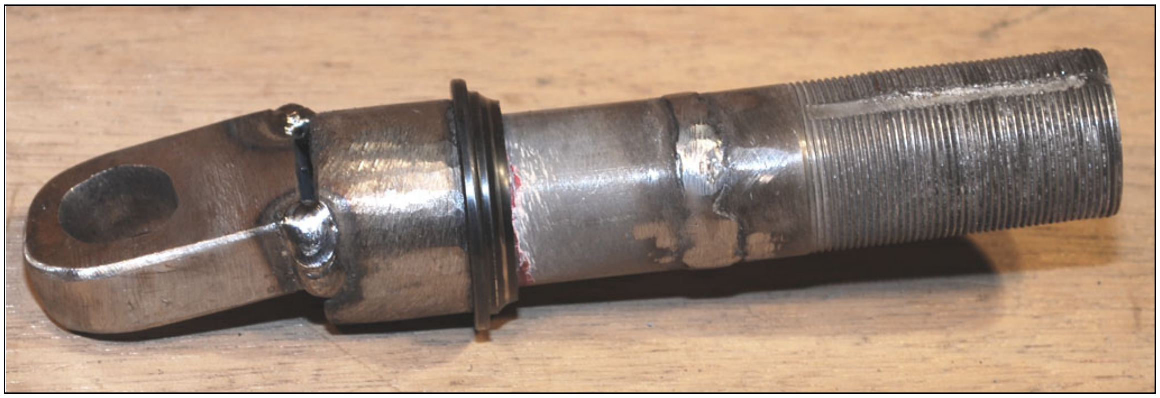

Figure 105 – Securing the axle tab to the crown

After you have used whatever bag of tricks necessary in order to tap the axle tab and fork stem into what seems to be the perfect center point angle, add a larger tack weld on each side as shown in Figure 105.

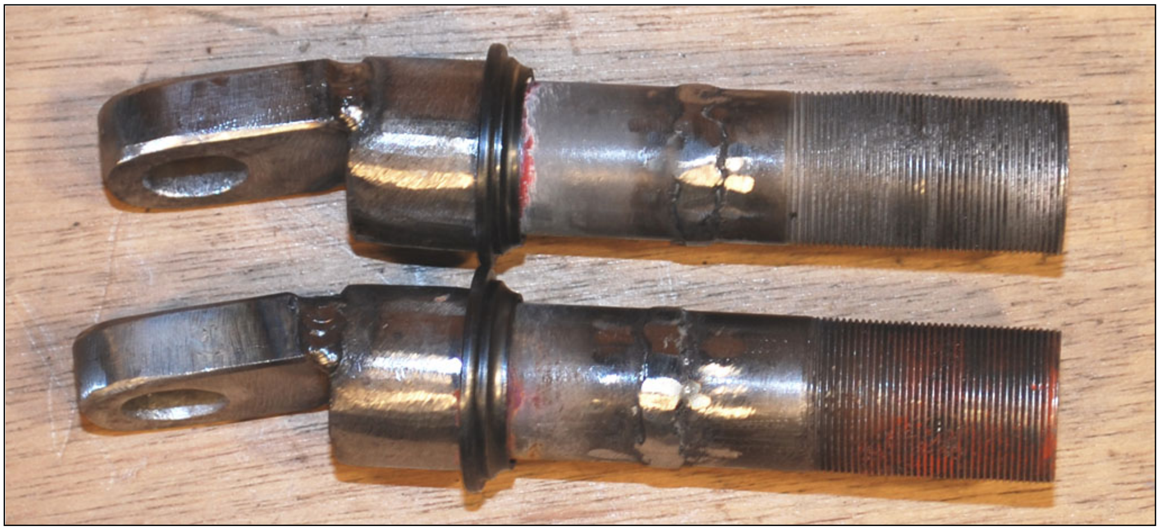

Figure 106 – Copy the second part from the first

The second axle tab can be built using the first one as a guide so that the match perfectly when placed together as shown in Figure 106. Another way to check them is to place the outside tabs facing together and check to see that both fork stems end up parallel to each other. Again, if it looks good, it probably is.

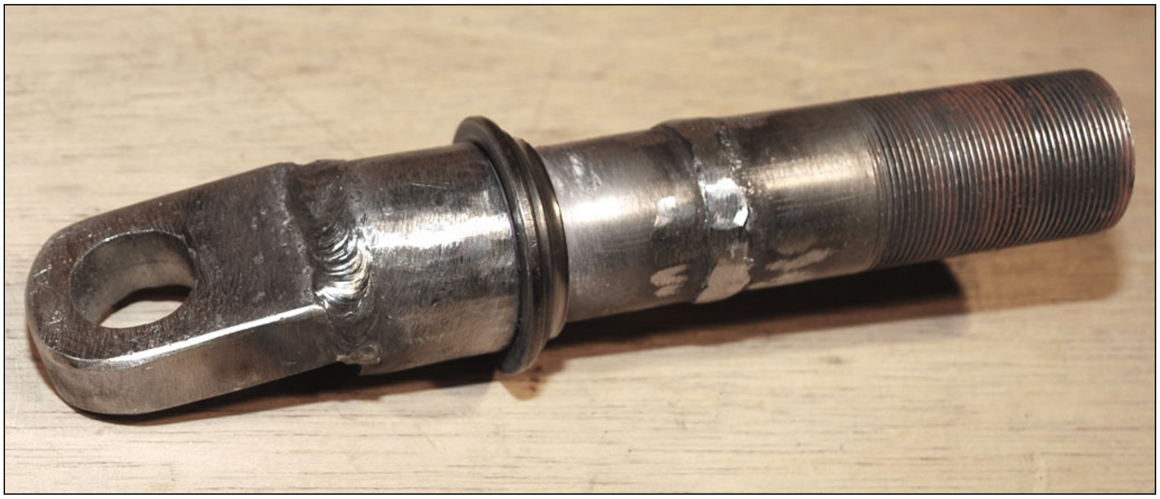

Figure 107 – Welding the inside joint

The side of the joint and the side closest the wheel will be easy to weld since there is very little gap, so weld them first. Whatever order you weld the first part, do the second one exactly the same way so if there is any slight distortion, it will be the same for both steering parts. Make this weld with the current turned up so you get good penetration into the thick plate and the stem.

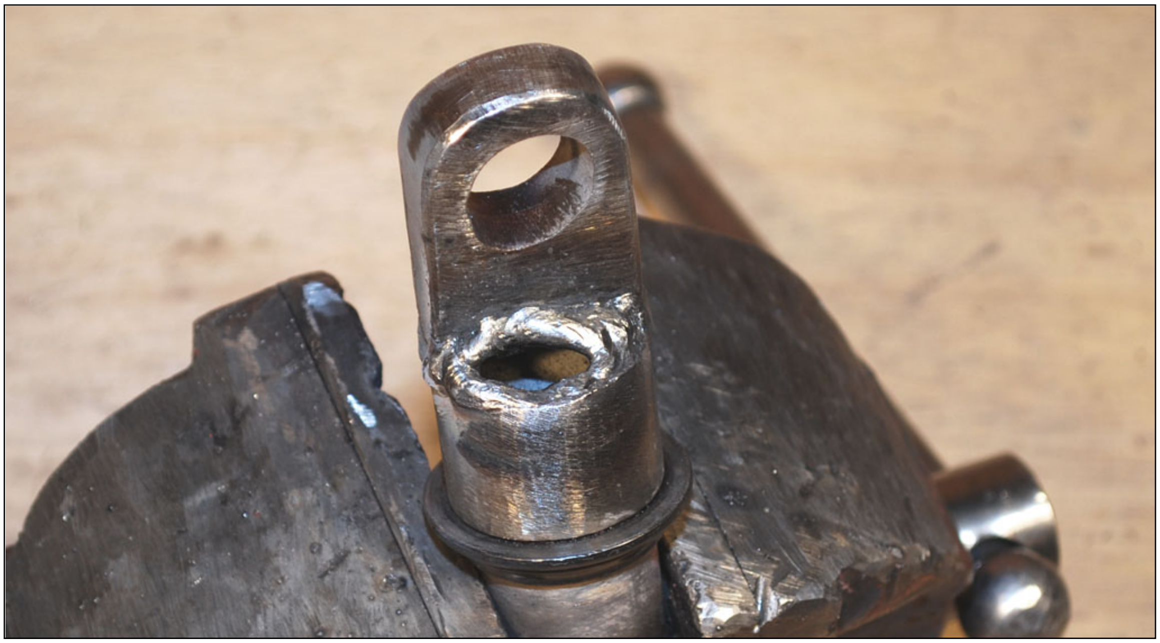

Figure 108 – This side will need the gap filled

The long side of the part will have a gap that needs to be filled as shown in Figure 108, so run a bead around the edges until the hole is filled. You could also jam some rod or plate in there first, but it only takes a few passes to bridge the gap with weld metal alone.

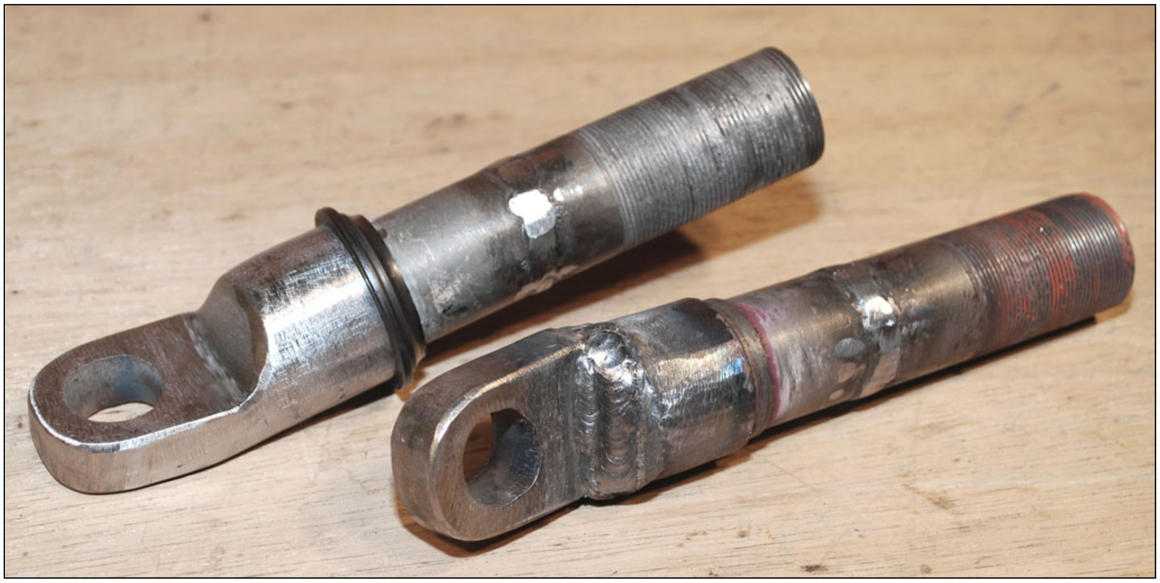

Figure 109 – Cleaning up the welded part is optional

If you like using your angle grinder as much as I do then, cleaning up the welds as shown in the top of Figure 109 will make your steering part look like it came from a factory. This was done in the usual fashion, using a rough disc to take away the access weld material and then a flap disc to polish it up. This step is optional, but worth the effort if you plan to show off your machine a lot.

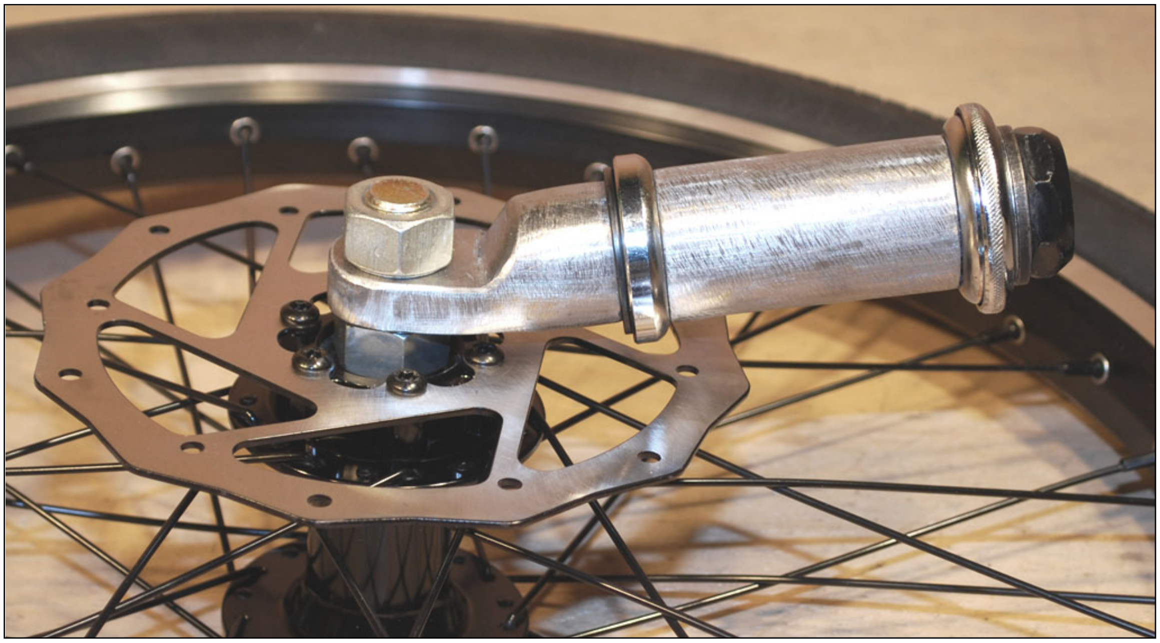

Figure 110 – Front wheel installed on the axle tab

One of the completed and cleaned steering assemblies is shown in Figure 110 after a little work with the flap disc. It’s hard to tell this part was once just scrap bicycle parts and some old rusty plate steel.

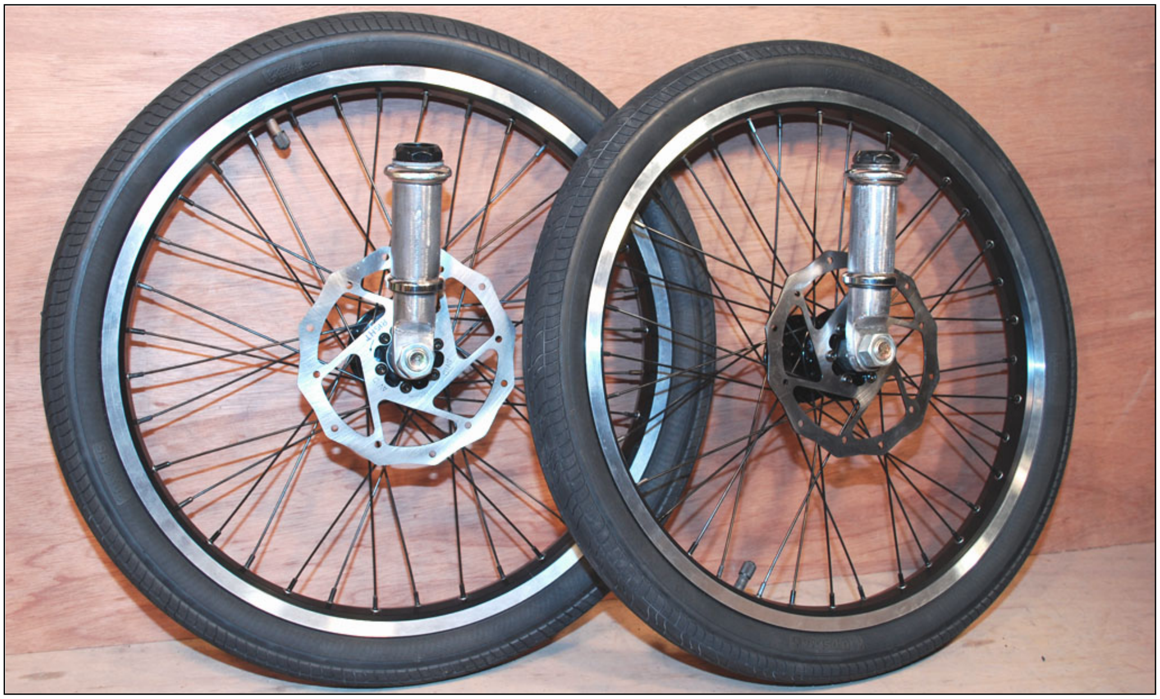

Figure 111 – Wheels and steering assemblies ready

Congratulations, you have completed one of the two complex steps in creating the Warrior steering system! You will be rolling down the street passing upright bicycles before you know it.

Steering Boom Tubes

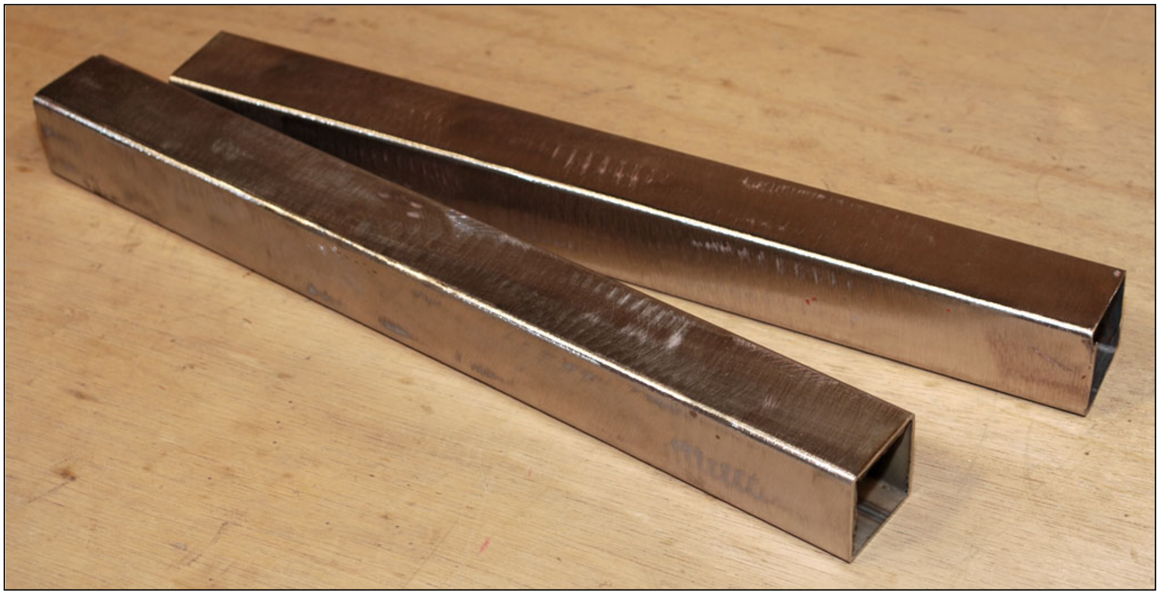

Figure 112 – These tubes become the steering booms

Since there are no real standards when it comes to trike frames, I will creatively name the next two tubes “steering boom tubes”. These two tubes are like wings that jet out from the center of the main frame to hold the wheels in place. To start with, cut two pieces of 1.5 inch square tubing to a length of 14.5 inches each. Complex angles will be derived from the actual frame again, so this is a little more material than necessary to allow for some error.

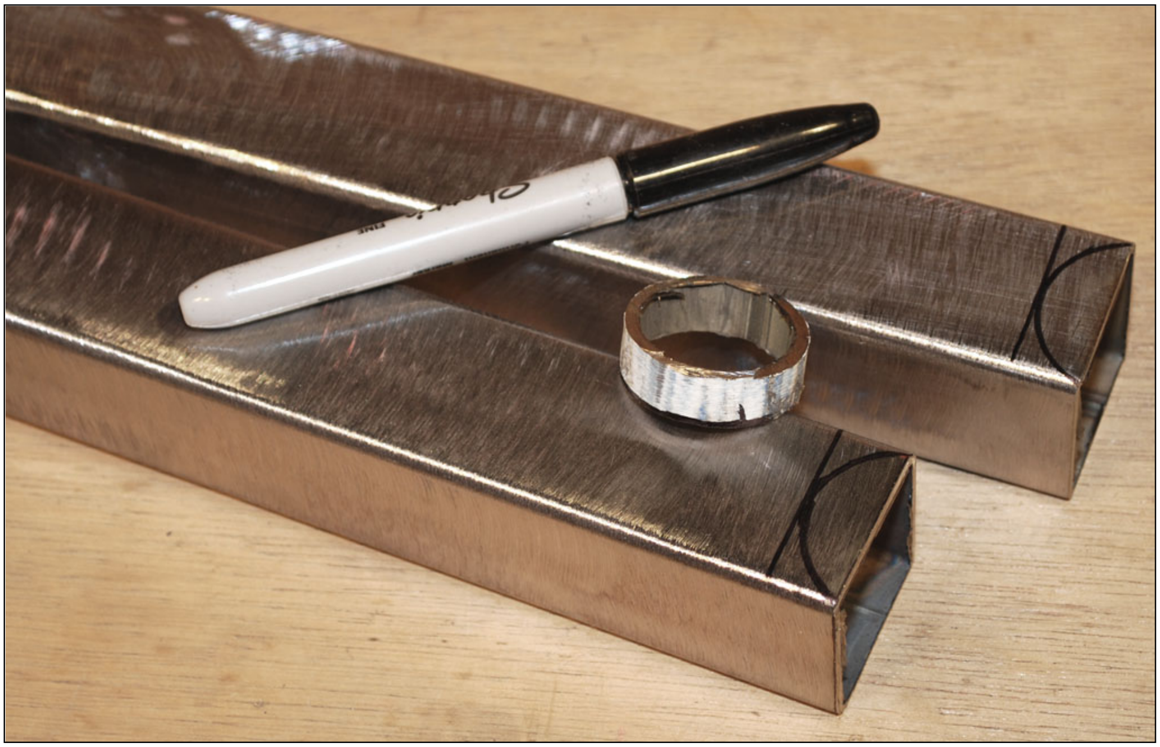

Figure 113 – Cutting fish mouths for the head tubes

One of the nice things with this frame is that there are no complex angles at the end of the steering booms were the head tubes must connect – just simple fish mouth cuts. The height of the frame and the angle created by the center point steering system make this possible. Use one of your head tubes or something with the same diameter to mark out a circular cut from corner to corner on each side of the boom tubes as shown in Figure 113. I use a grinder disc to remove the metal, but a hacksaw and round file will also do the job if you like the exercise. The goal… to make all four fish mouth cuts the same.

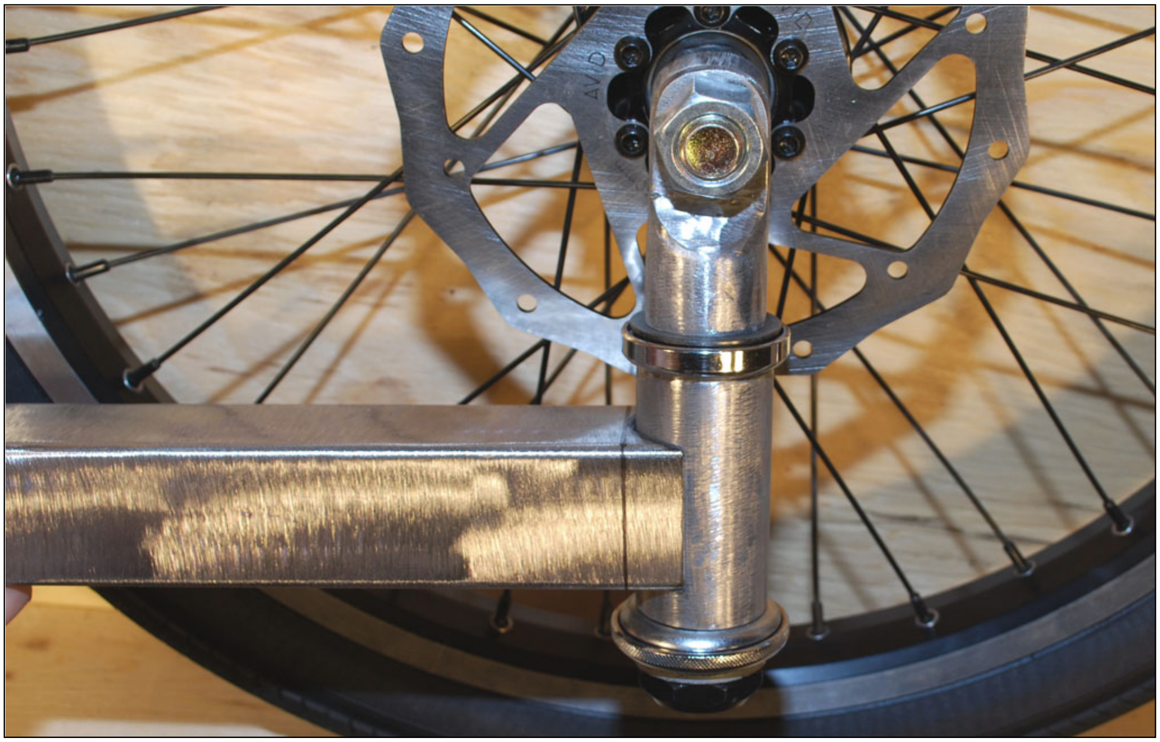

Figure 114 – Checking the fish mouth cuts

The gap should be as minimal as possible once the four fish mouth cuts have been made. As shown in Figure 114, there should be a perfect 90 degree angle formed between the head tubes and the boom tubes as well. Don’t worry about a few small gaps though; you can easily fill them when welding the joint. The 90 degree angle is the important thing to get as close as possible.

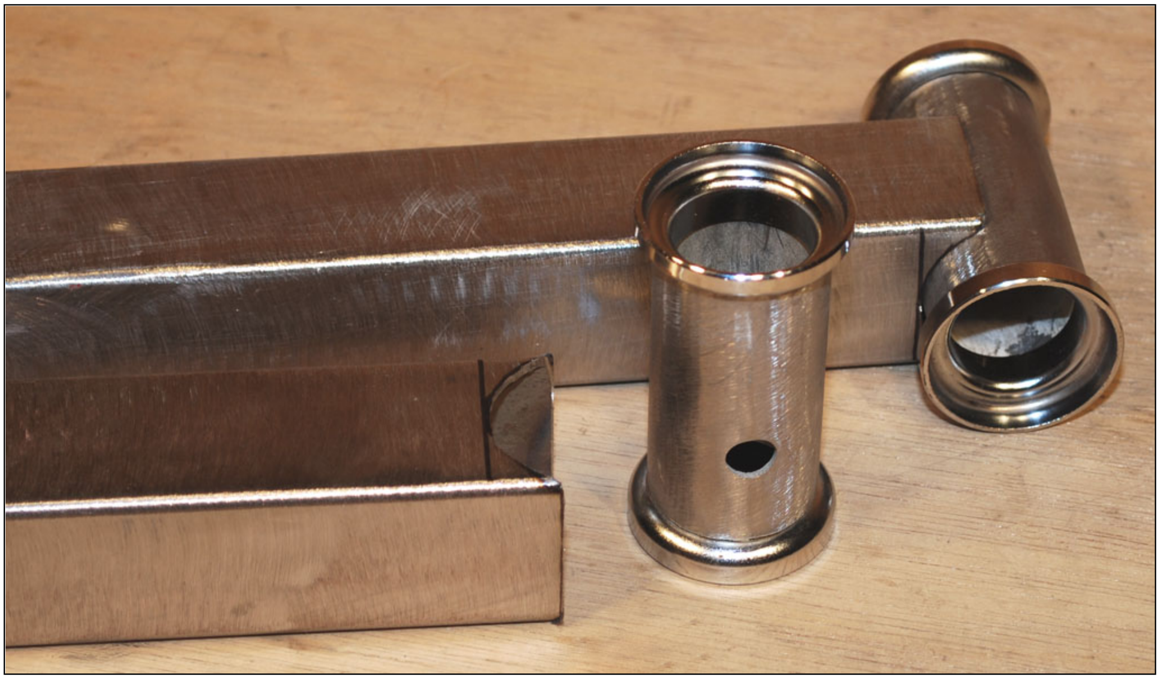

Figure 115 – Ready to weld both head tubes

The holes in the head tubes (Figure 115) should be placed inside the square tubing when installing the head tubes. Also check to make sure the fish mouth cuts are even so that the head tubes are installed at 90 degrees to the boom tubes. A good visual check can be done by holding the boom tub straight up with a longer round tube sitting in the cutout. It should form a 90 degree T when you look at it.

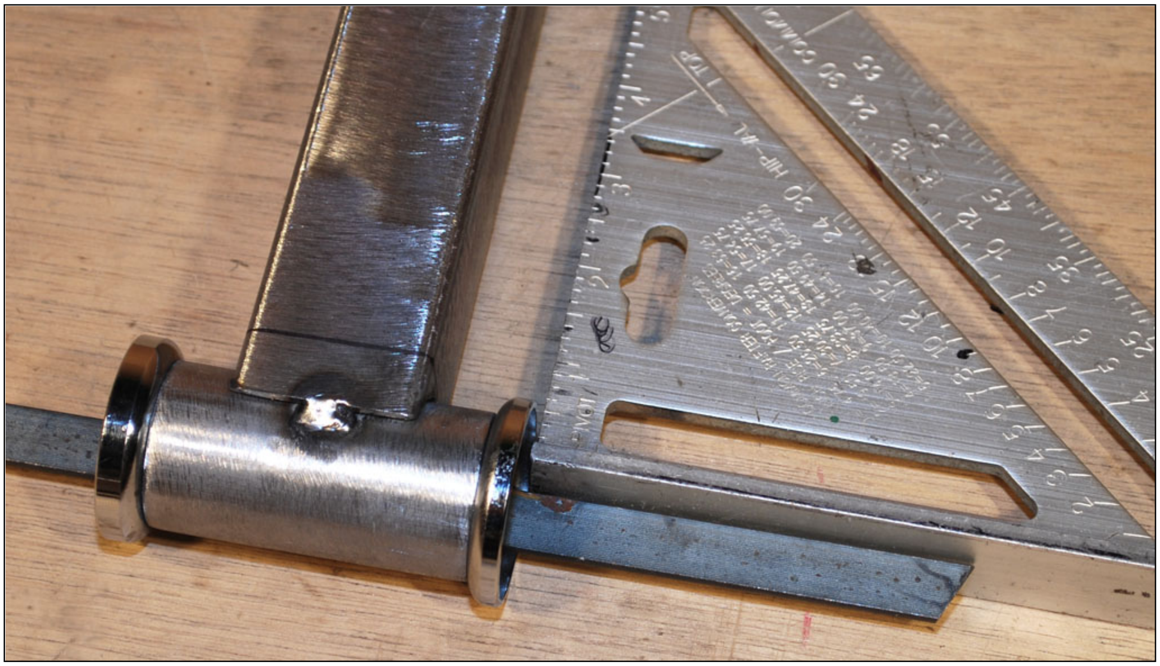

Figure 116 – Tack welded head tube

The head tube will be installed so that it is centered on the boom tube as shown in Figure 116. Place a good tack weld in the center on both sides and then check the alignment one more time. A straight edge placed into the head tube should form a perfect 90 degree angle with the boom tube. A few hammer taps can easily set things straight.

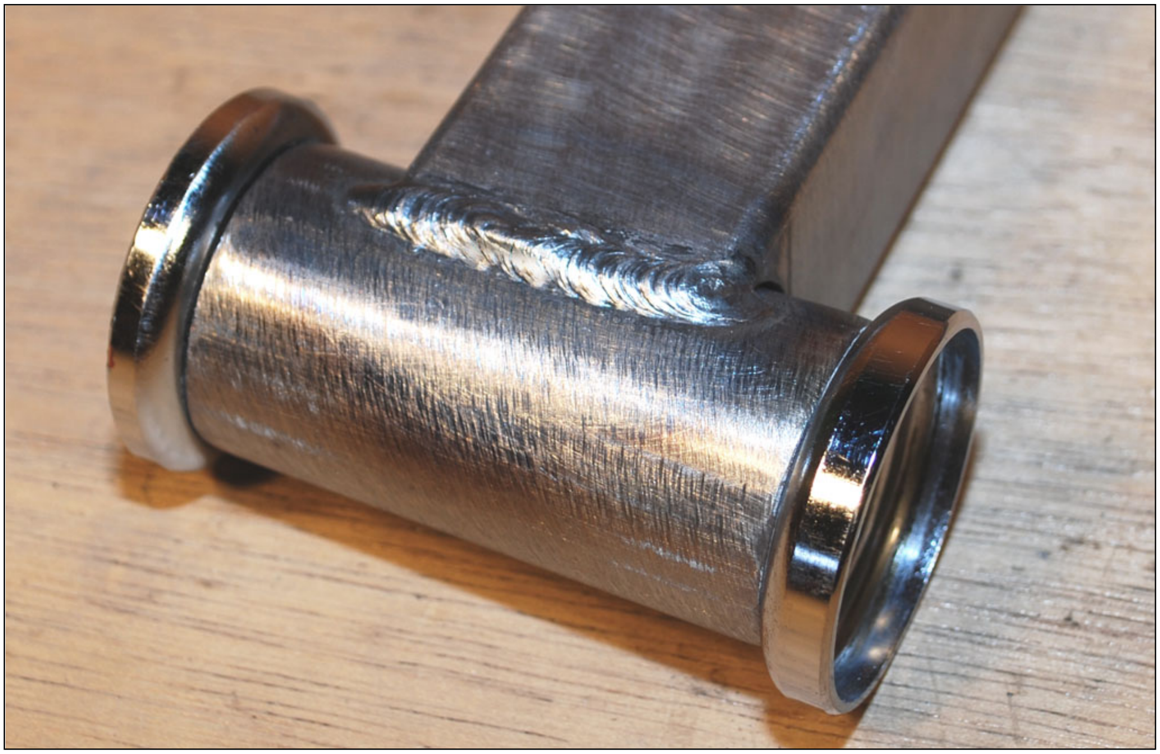

Figure 117 – Weld the sides of the joint first

To maintain the 90 degree angle as much as possible during welding, start with the sides of the joint as shown in Figure 117. It's also a good idea to leave the cups installed so that the head tube is not distorted into an oval shape after welding. If you don't trust your steady welding hand so close to your good cups, use an old set, or put some tape around them on each weld pass.

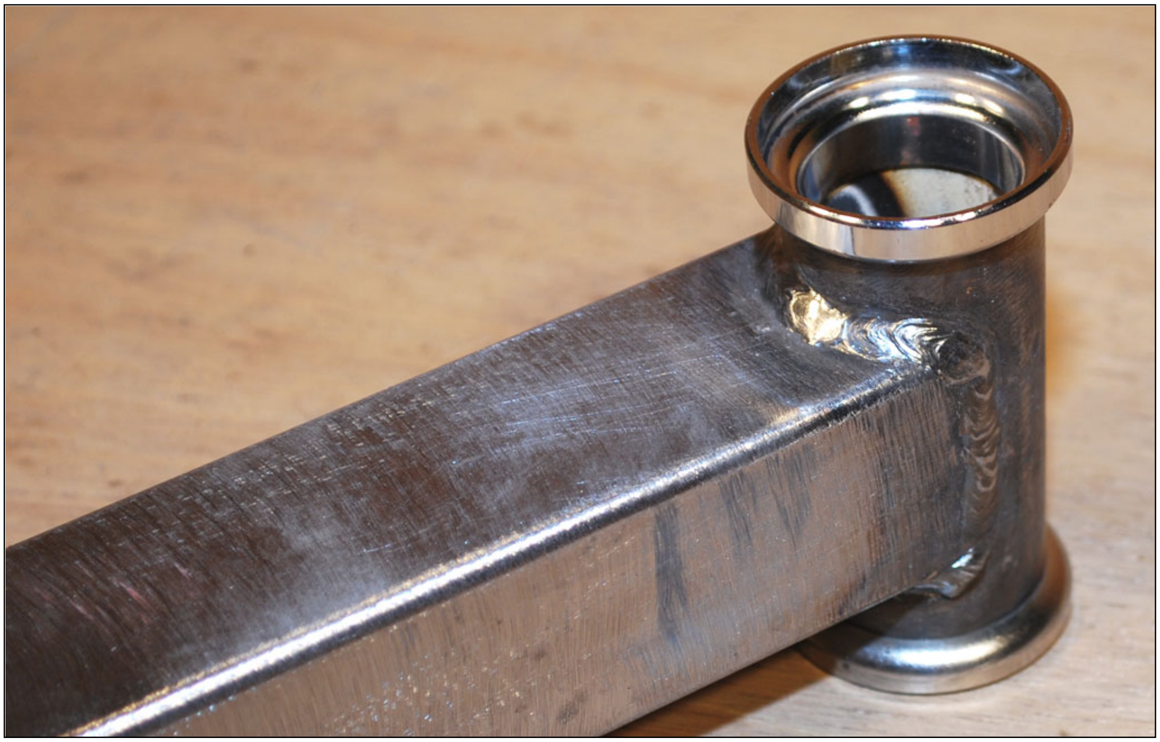

Figure 118 – Head tubes completely welded

Once the sides of the joint are welded, you can finish the top and bottom of the joint as shown in Figure 118. There should be very little distortion after you are complete, so the 90 degree angle will remain as close as you started.

Make the Seat

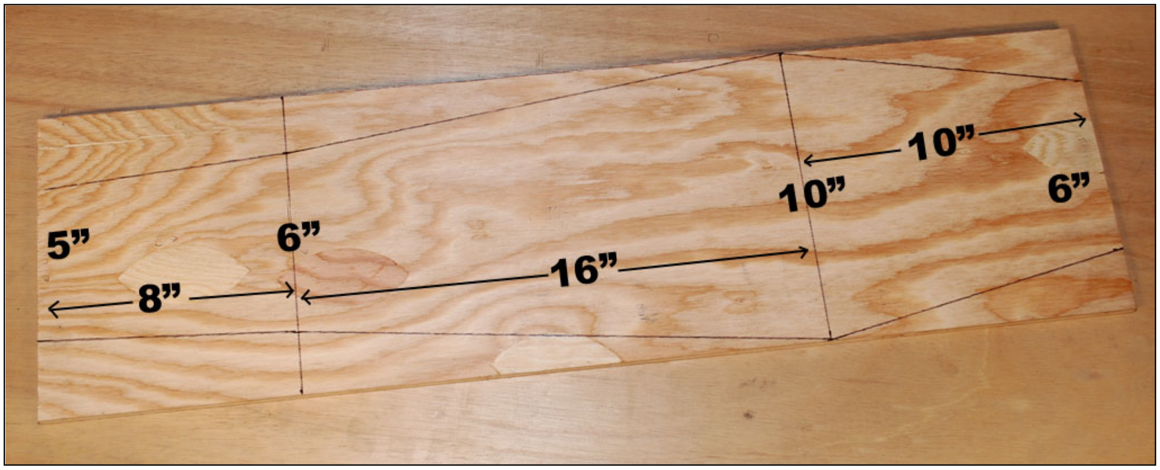

Figure 119 – Making a simple wood and foam seat

Before you complete the last difficult step in this build (installing the steering booms), you should build your seat, just to be sure you have all of the proper clearances when you are done. It’s nice to take a break from the complex stuff every once in awhile, that’s really why I changed pace for now!

Much like handlebars, seating is a very personal thing with many options. Seat construction is totally up to you, and there are hundreds of different materials you could use to make a great seat depending on your personal preference. I like a hard seat that lets me easily shift my weight around, yet offers a little bit of padding from the rougher terrain. This hard black foam needs no covering, will not soak up moisture, and is very resistant to wear.

It may seem like something like this would be uncomfortable, but to be honest, I can sit in this seat all day long with no pain at all, but can barely take two hours on an upright bicycle without a break. The dimensions I chose are shown in the three boards in Figure 119, but feel free to alter them to fit your body. If you plan on making a mesh seat, then your seating will be a bit higher due to the fact that some room between the underside of the material and frame will need to be added. Composites like fiberglass and carbon fiber are also alternative materials that can be made to form a custom seat.

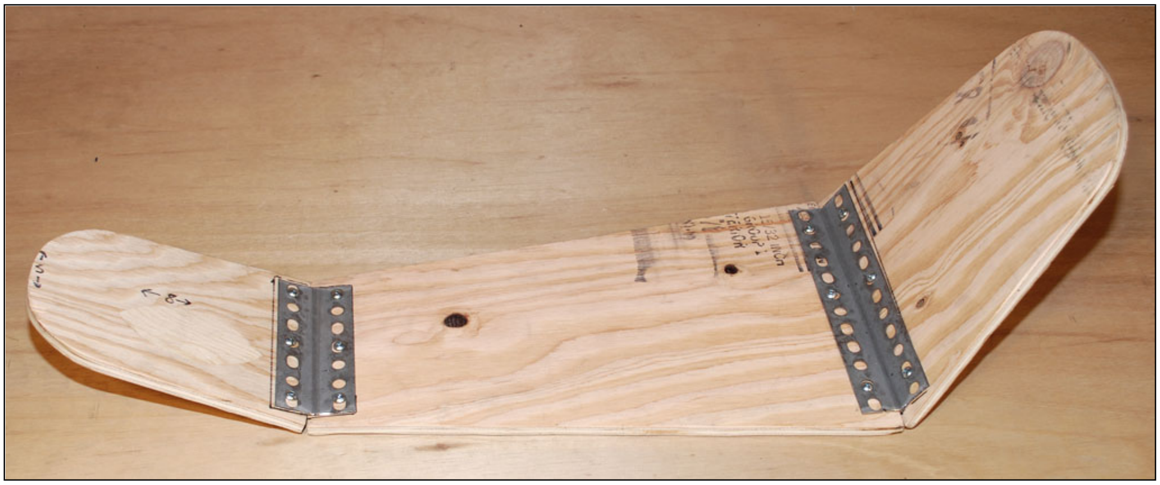

Figure 120 – Making a strong seat base

As shown in Figure 120, the three seat halves are held together by a pair of shelf brackets that I hammered into the correct angle. The foam will be glued directly to the wood using spray adhesive, and then trimmed by following the edge of the seat board with a sanding disc in the grinder. The metal brackets can be easily bent to alter the angle of the seat if necessary.

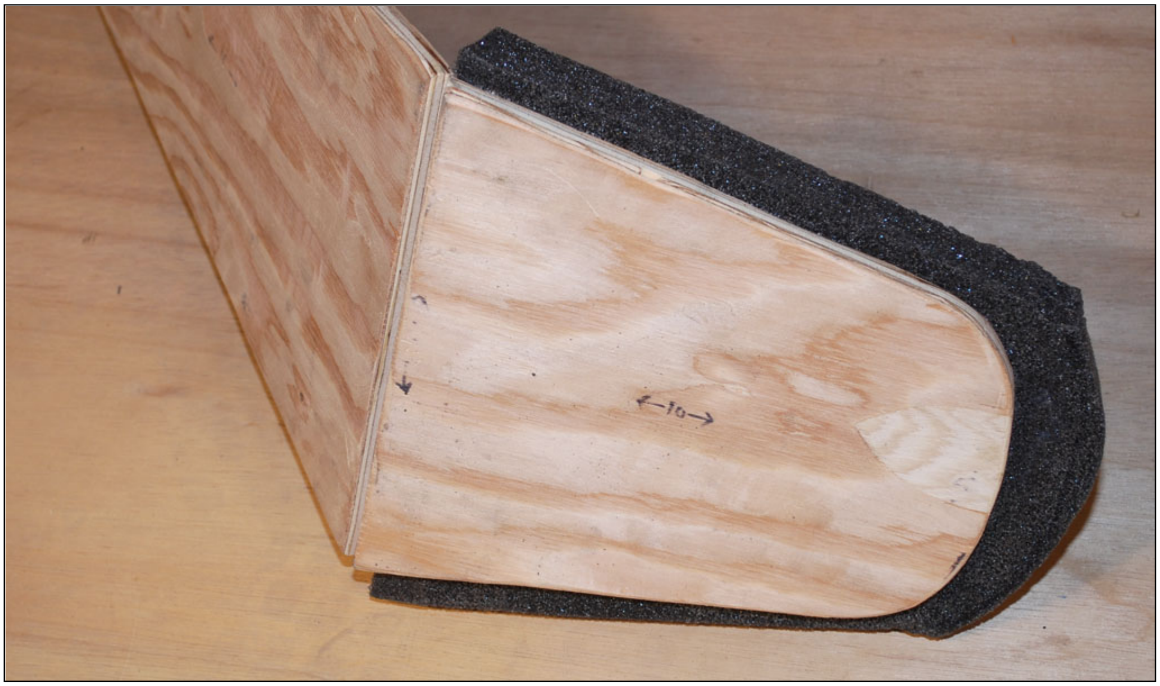

Figure 121 – Gluing down the rigid foam

Foam comes in all sorts of styles and hardness, so you might want to visit your local upholstery or fabric shop to find something you like. Avoid the temptation to cut up an old chair and salvage the foam, as it will probably be way too soft, and will certainly need a covering. If you have a few bucks left over in your budget and don't enjoy upholstery, just drop of your completed seat base to an upholstery shop and get them to make you a decent seat. Tell them you want something as comfortable as a boat seat, but not as hard as a bicycle seat. Figure 121 shows the first foam piece after gluing it to the wood.

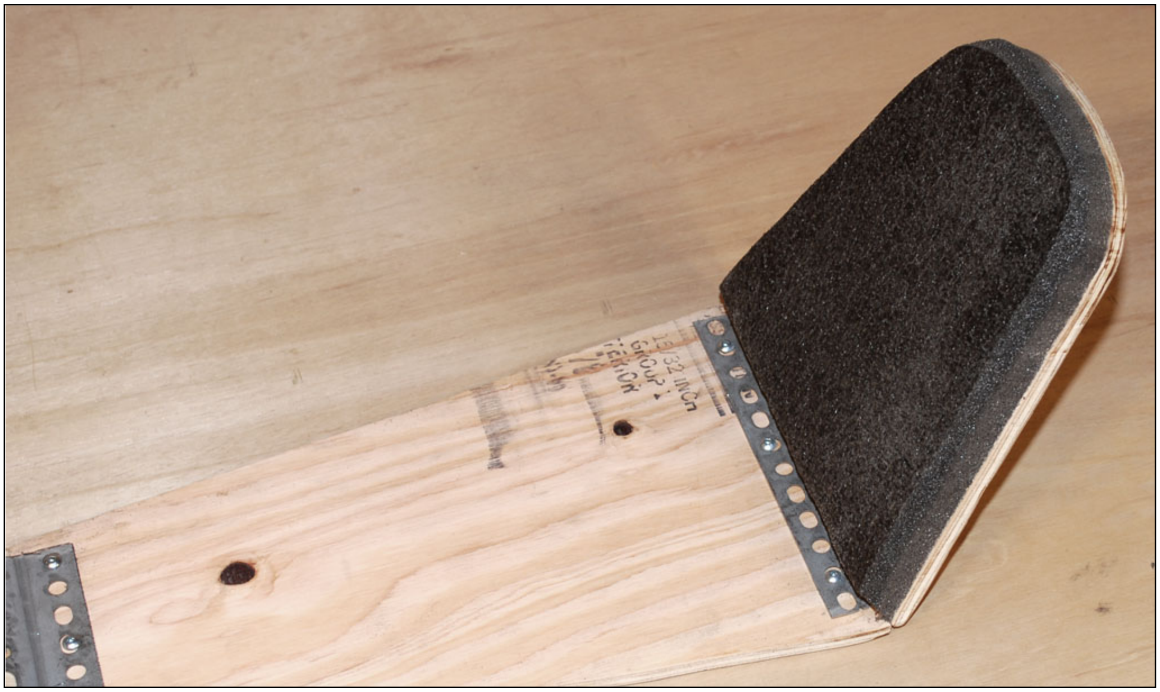

Figure 122 – Using the angle grinder to trim foam

My angle grinder is the king of the garage! I use it to cut all my tubing, hack up bicycles, fix welds, sand away stickers, cut wood (really!), and even trim foam. As shown in Figure 122. By carefully following the edge of the wood using a flap disc, the foam gets perfectly trimmed around the seat. I then finish it off by beveling the top slightly. Who said a grinder is just for metal? The other piece of foam for the back of the seat is made the same way and glued to the board. Next, we will complete the frame.

Building the Steering Booms

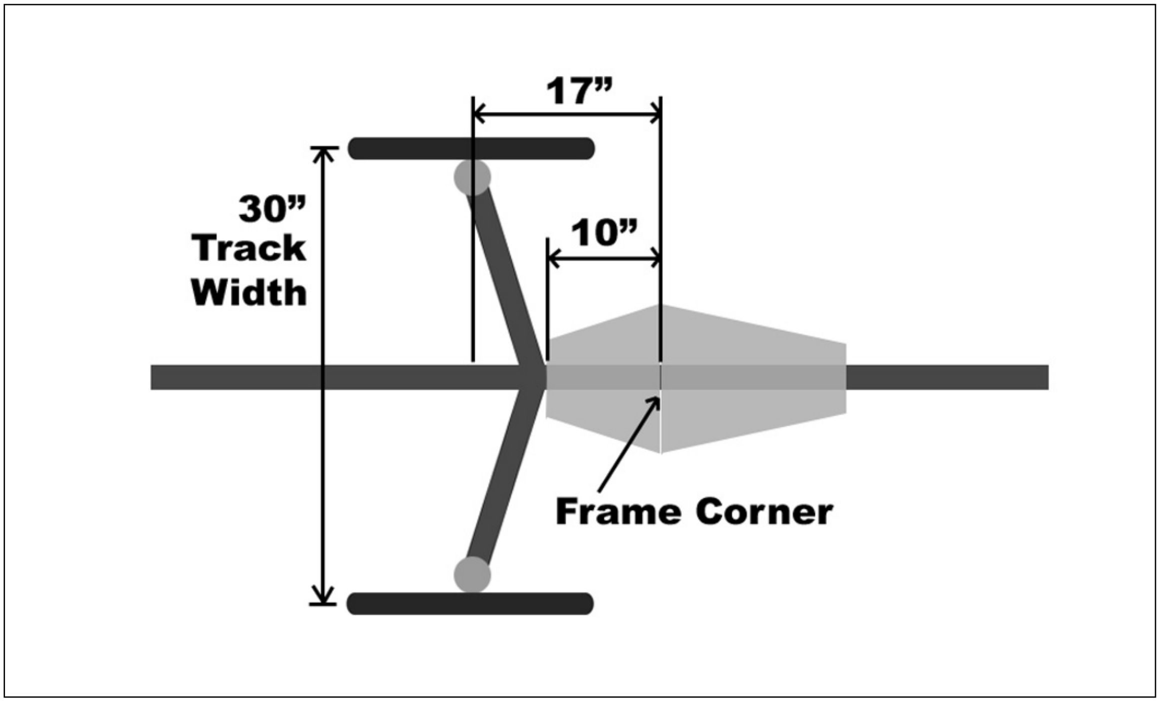

Diagram 6 – Wheel position and track width

The position of the front wheels as well as the track width (width between the tire centers) is shown in Diagram 6. This front wheel position and angle of booms solves several design challenges at the same time. Being on an angle, the two booms allow for extra clearance for the heels of riders shorter than 5 foot 8 inches.

Since it’s made from square tubing, the angle of the boom when welded to the frame boom will automatically create the needed caster angles for self-centering steering. Because of the position of the boom tubes on the frame as well as the center point angles in the head tube, the height will automatically bring the front wheels into 90 degree alignment with the ground. The position of the wheels relative to the seat also allows full steering with no leg or pedal overlap, so there are no design quirks you have to live with.

The bad news is that it is still going to take a fair amount of trial and error grinding or filing to make the correct cuts at each end of the boom tubes, so proceed only if your patience level is high today!

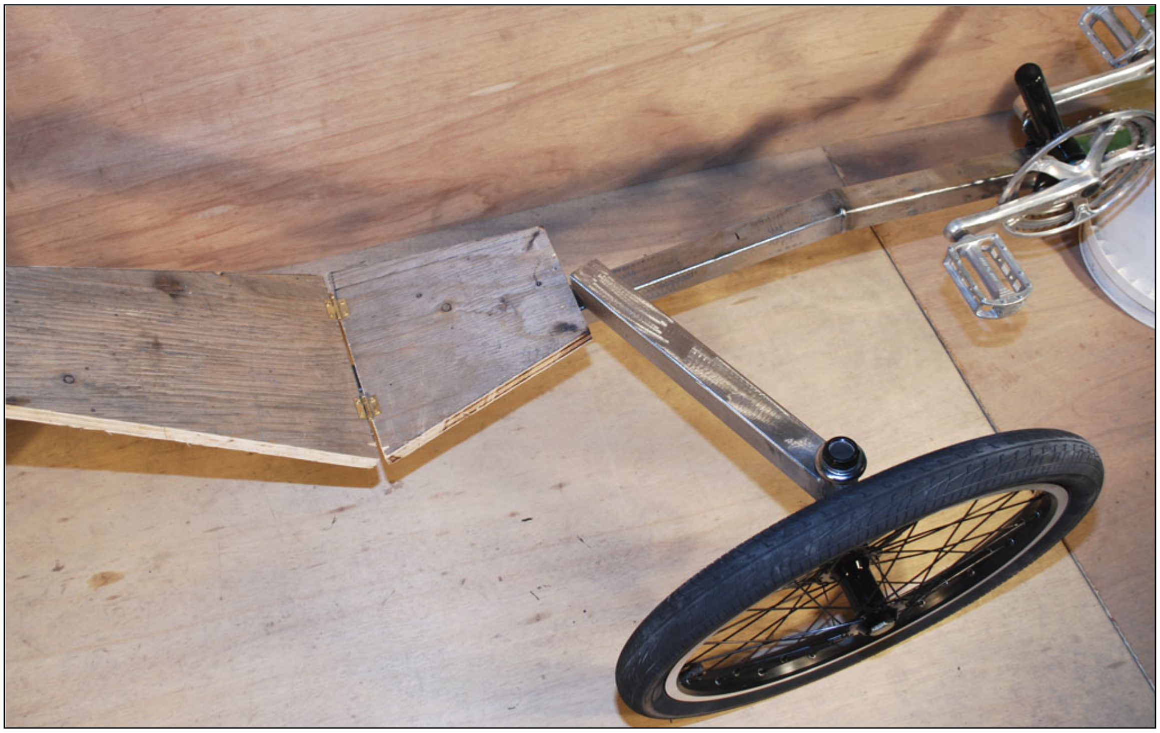

Figure 123 – Demonstrating the wheel position

Since the two steering boom tubes were made a little longer than necessary, you have some room for error when making the compound angle cuts that will be needed at each end. As you can see in Figure 123, there is a good 1.5 inches of extra material overlapping the frame when the wheel is placed as close to Diagram 6 as can be done by eye. To help keep the wheels from turning, remove the top bearing and crank down the fork hardware so the friction will keep the wheel in the position you want. A lot of this alignment will be done by eye, so if you want to play it safe, take off less than you think you need and then grind a little at a time.

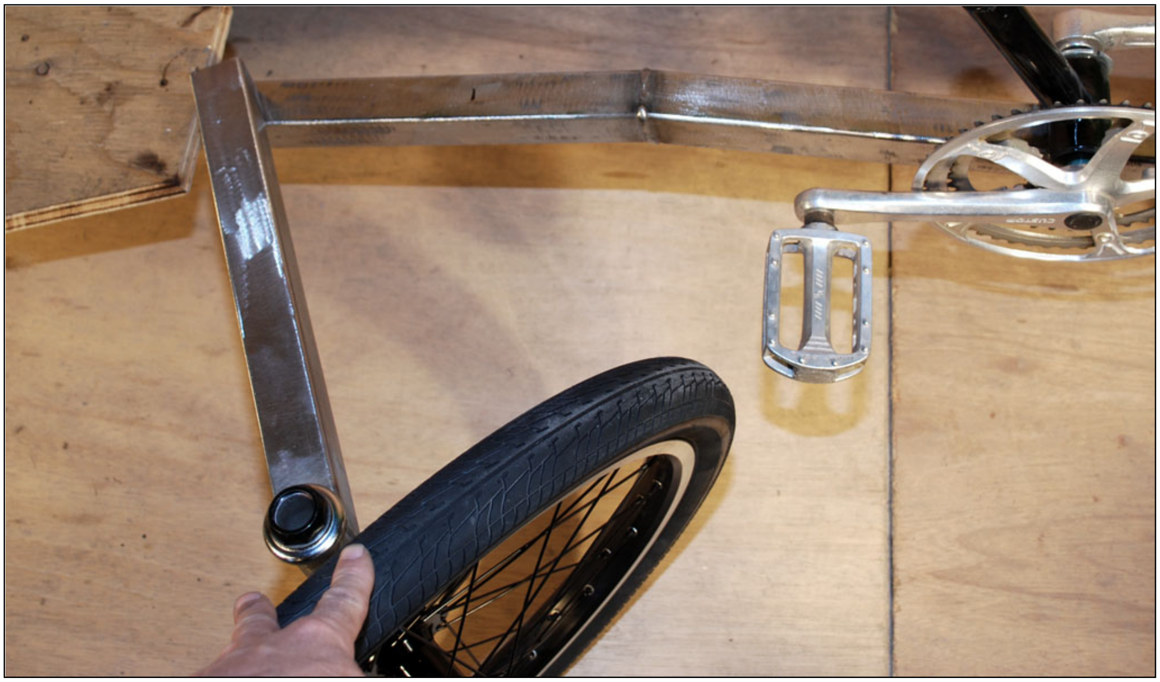

Figure 124 – Checking the wheel and pedal overlap

Figure 124 shows that there will be no pedal and wheel interference, even when the bottom bracket is set for riders with a very short inseam. Because a tadpole trike has such a short wheelbase, the front wheels only need to turn about 35-40 degrees in order to make a nice sharp u-turn, so there will be no issues here.

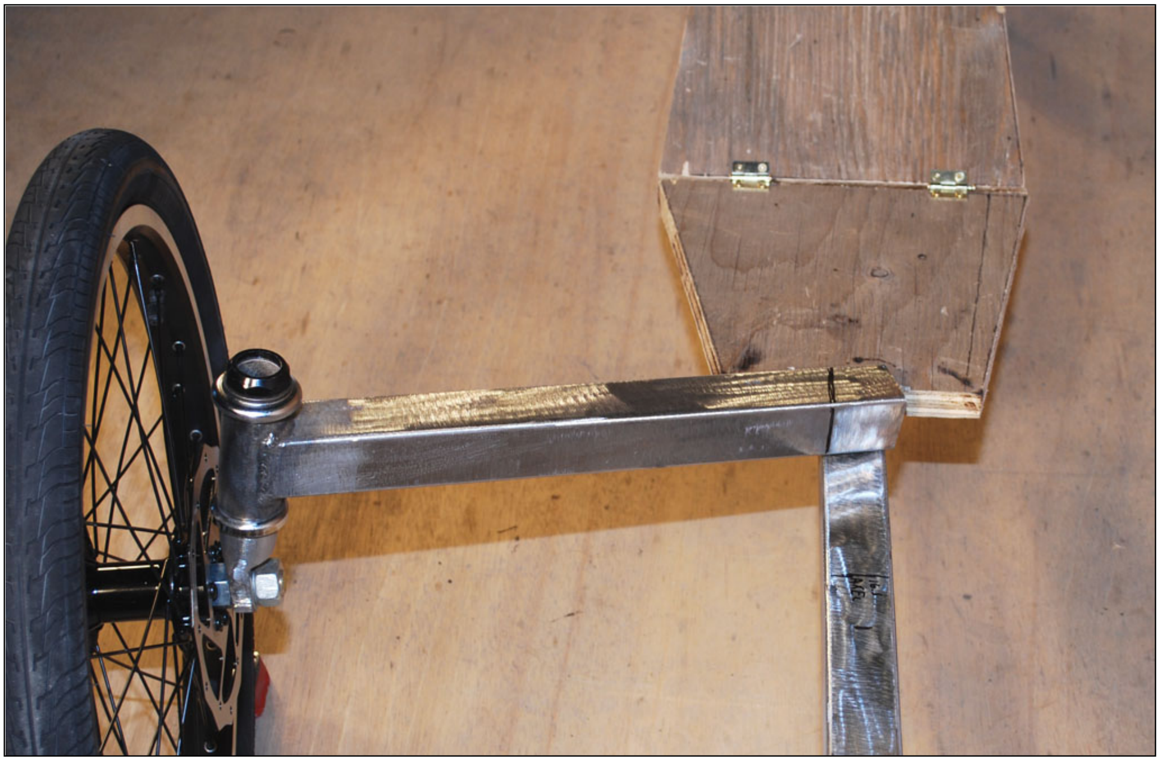

Figure 125 – Beginning the careful boom trimming guesswork

The next step is called “guesstimating”, and depending on your garage hacking experience, might take a few tries to get right. The process sounds so simple; just place the wheels in their correct position, and then mark a line on the boom where it needs to be cut. The problems become apparent if you overestimate and trim away too much of the boom, which will result in a narrower track width. Although you don’t have to be perfect, the closer the better here, so if you don’t trust your guesswork all that much, make your best guess then trim a good inch outside your line at first. It is much easier to trim the boom a few times than to grind off the entire boom from the head tube and cut a new one due to a huge mistake.

I had to make and grind my cuts three times to get the boom exactly where I wanted it, and the good news is that you only have to do this for one side, since the angles can be transferred to the other boom using a square.

One thing that is important is that the frame is propped up according to the 11 inch front boom ground clearance and that the rear wheel has an inflated tire and is standing perfectly vertical to the ground. Take your time, triple check your measurements and everything will work out just fine!

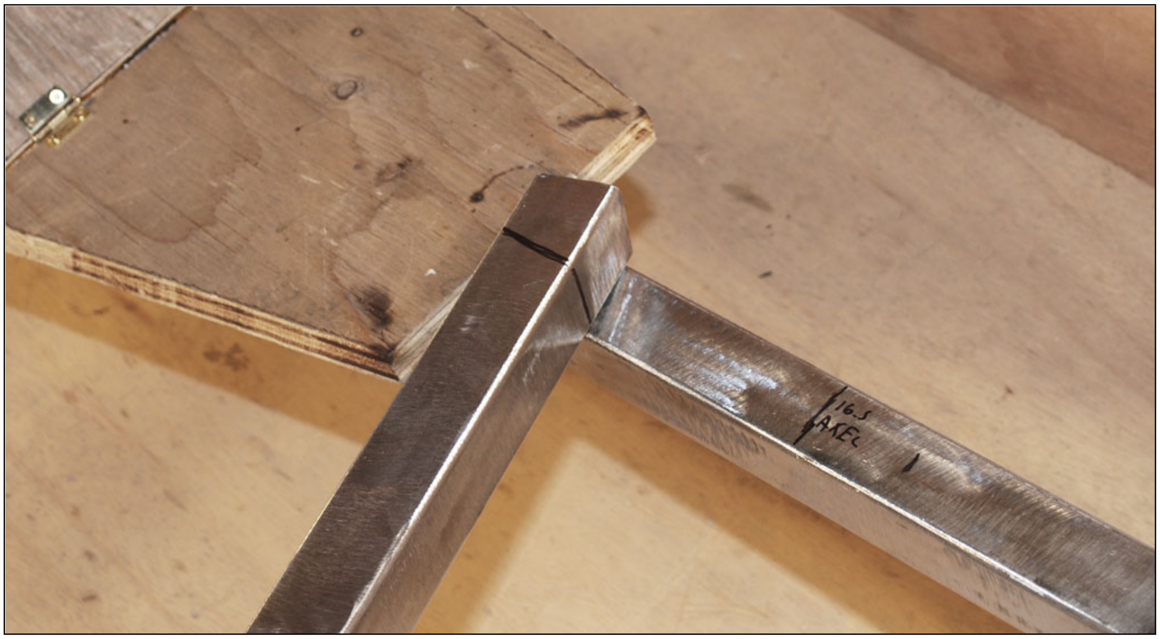

Figure 126 – Checking the angles from all perspectives

I placed the steering boom over the frame in order to use it as a guide, which works well, but remember that you will have to lower the front by 1.5 inches due to the height of the frame boom tubing. If you don’t lower the front, your cult line will be slightly off since the steering boom is welded to the side of the frame boom, not onto the top.

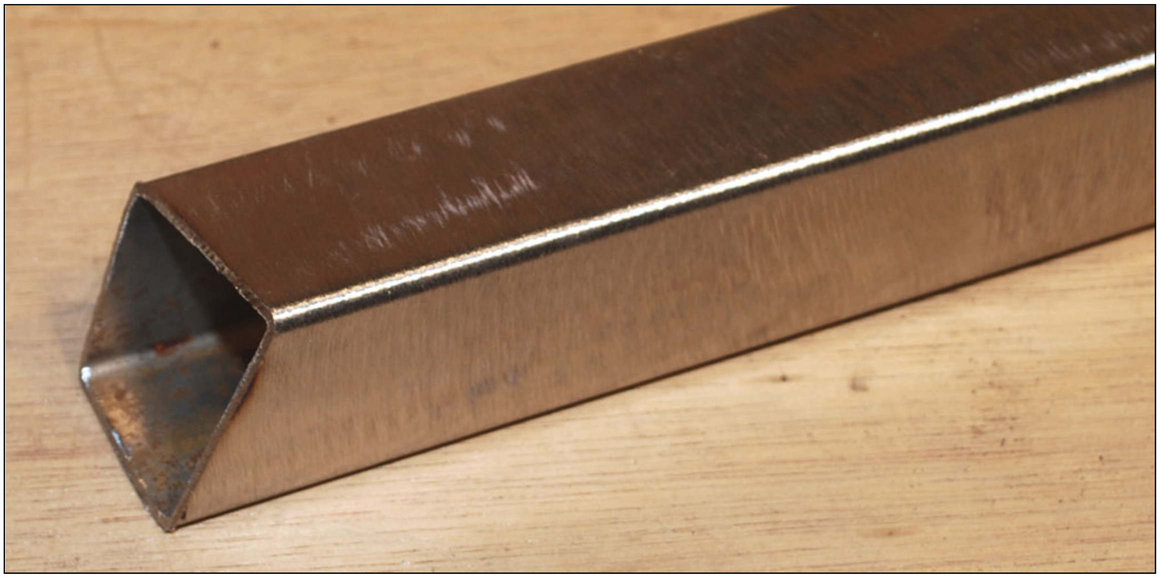

Figure 127 – A close-up view of the bizarre boom cut

The final cut that was eventually made on the end of the steering boom (Figure 127) looks like a hacksaw job that went horribly wrong, but this is what it looked like when I was done grinding for the third attempt. The joint is not perfect, but the gaps where no larger than 1/8 inch, so a little filling with the welder will be easy. A lot of correction can be made later once the steering booms are actually tack welded to the frame, so don't worry about perfection here.

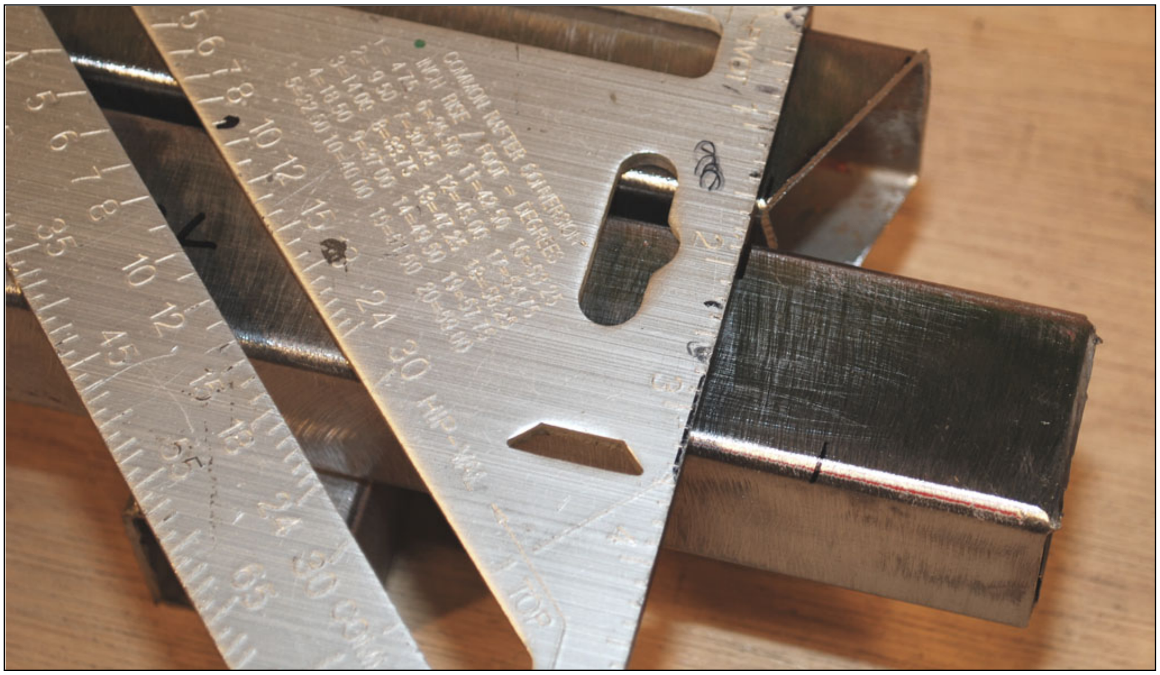

Figure 128 – Mirroring the angle to the other tube

There is no way you will ever make the other side exactly the same using the "best guess" technique, so the line transferring method has to be used here. You will need a square to mark points from one tube to the other as shown in Figure 128. Remember, that this is a mirror image, to when the tubes are place together; angles are opposite to each other (see next figure).

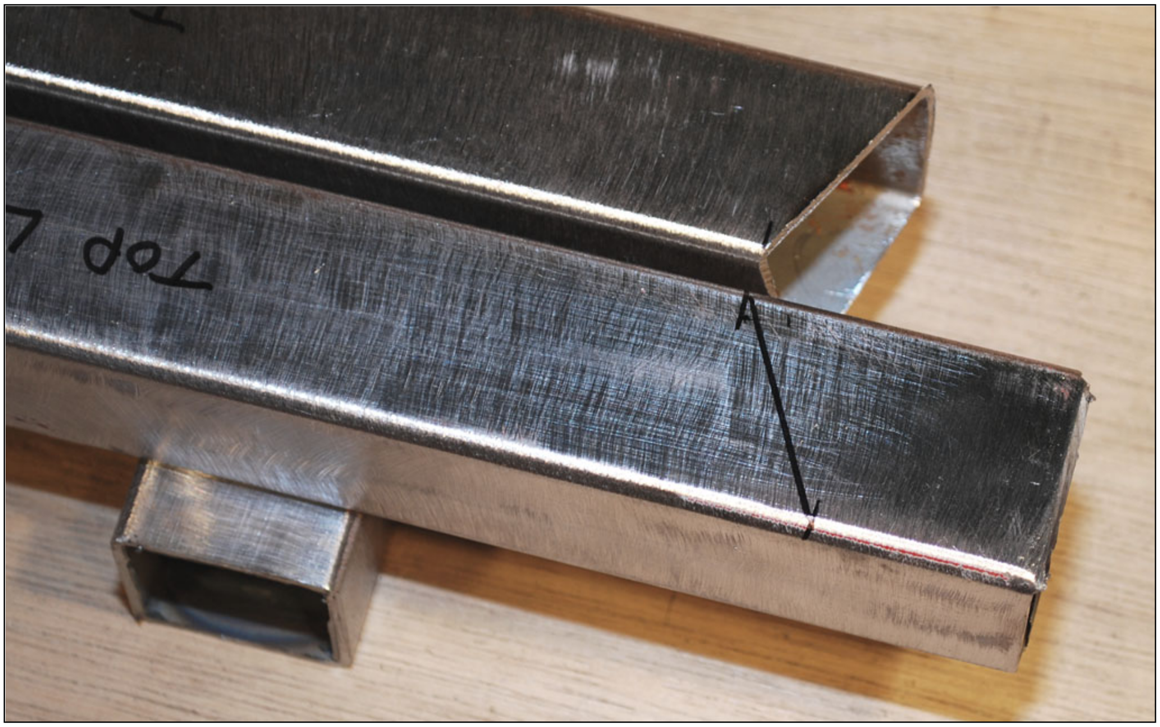

Figure 129 – Creating mirrored angles on the other tube

A mirrored angle runs opposite to the one next to it as shown in Figure 129. It is also important that both steering booms are sitting on a perfectly flat surface and that the head tubes are inline with each other while doing the line transfers. Placing the head tubes up against a wall helps to keep them inline with each other. This mirror transfer is done on the top and bottom of the tube and then the sides are linked together by marking a line from point to point using a straight edge. This way, you only have to mirror the top and bottom angles.

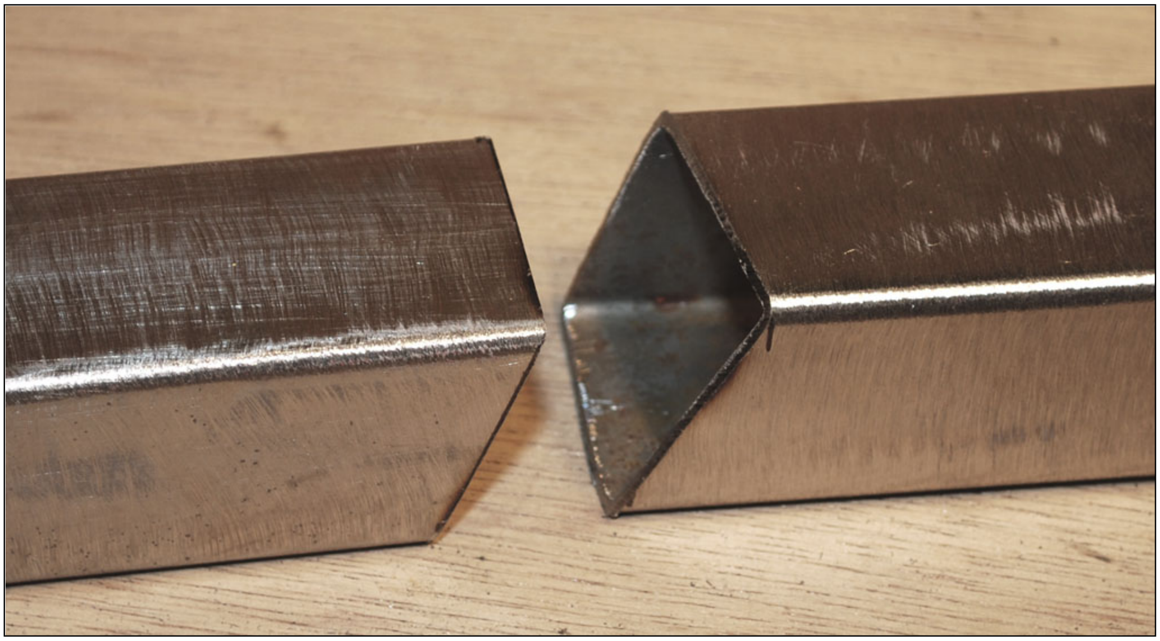

Figure 130 – A simple test for the mirrored cuts

If you made an exact mirror on the other steering boom, the two should link together to form a straight tube. As you can see in Figure 130, I could push the ends together and it would appear that they were originally cut as a single tube.

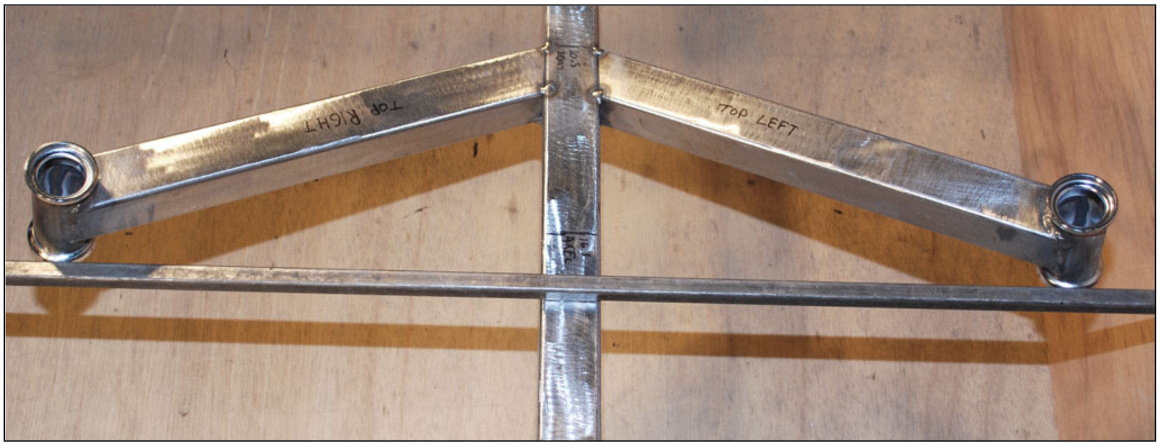

Figure 131 – Tack weld the steering booms and check angles

The two steering booms are tack welded to the frame so they are 10 inches from the top corner formed between the rear seat tube and center boom tube. This is shown in Diagram 6. A lot of close visual inspection will need to be done in order to ensure that the booms are at the correct angles and that they create a perfect mirror of each other. Placing a straight tube across the head tubes as shown in Figure 131 is a nice way to check forward angle as well as the height of each head tube. With a good tack weld on each corner, you will also be able to carefully install the steering hardware and do a visual check with both front wheels as well. Take your time here, and make sure the booms are where they should be before committing any more welds to the joint. If things have gone terribly wrong, break the tack welds and fix the joints!

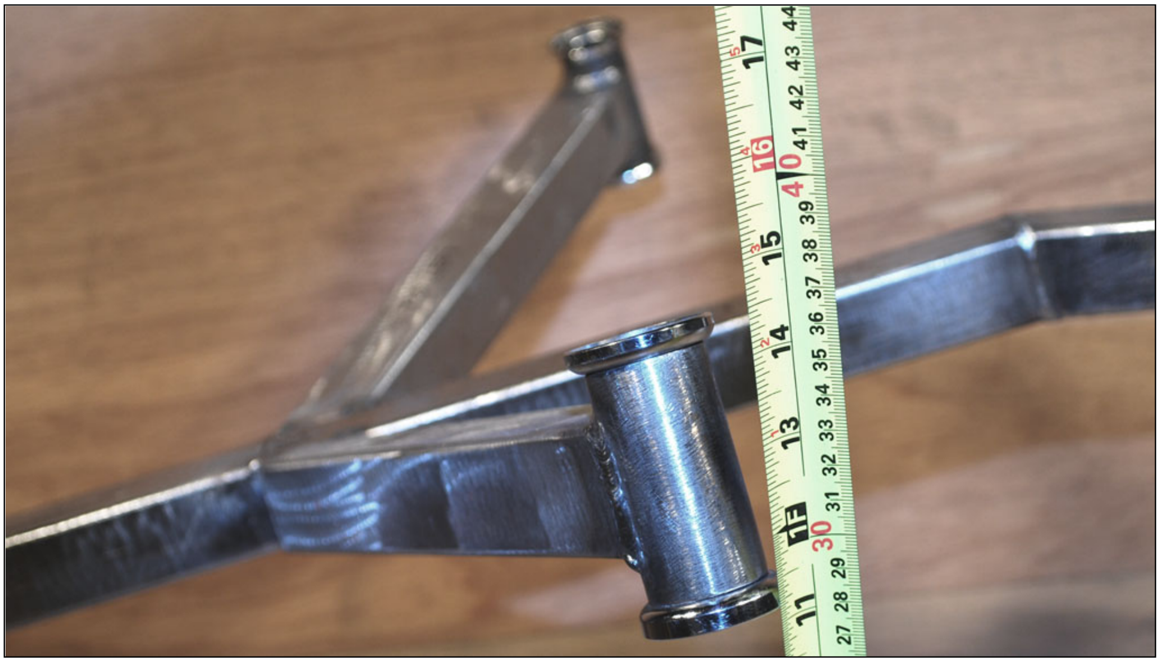

Figure 132 – Head tube heights should be the same

With the frame sitting perfect horizontal so that the rear wheel is at 90 degrees to the ground, both head tubes need to be the same distance from the ground. Of all the slight misalignments, this one will be the most noticeable, as your trike will lean to one side. Believe it or not, some trike manufacturers have made the right side of their tries slightly higher than the left to compensate for the slop in the road as you drive on the right side. I cannot fathom building a non symmetrical trike, so I would never consider such a move, although I found it interesting. I like symmetry!

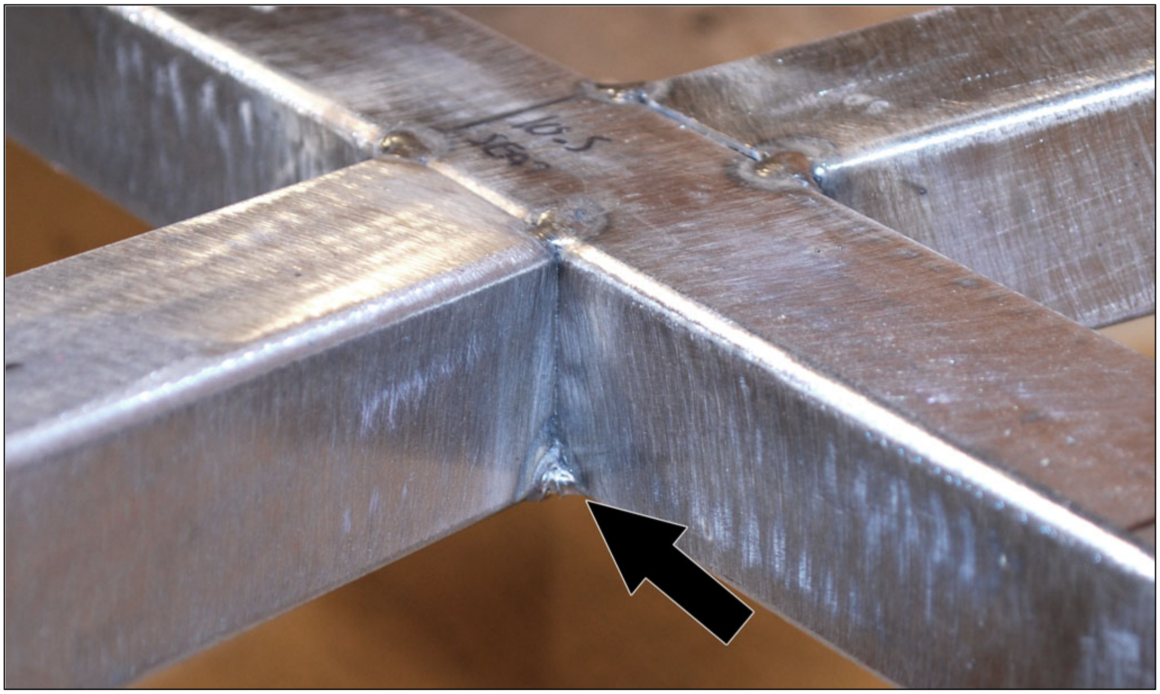

Figure 133 – Four tack welds seal the deal

Once you have added two more tack welds on the underside of the joint as shown in Figure 133, it will be easier to manipulate the frame with the steering hardware installed. These tack welds also commit your angles, so only make them once you have meticulously mulled over your frame for hours, tapping it with a mallet wherever it needed a little fine tuning. Ok, it wasn't all that difficult really – I went from boom cuts to this step in about half an hour. Being a perfectionist at this point is worth it though, as it will be easy to see a trike that leans to one side.

Check Angles and Weld

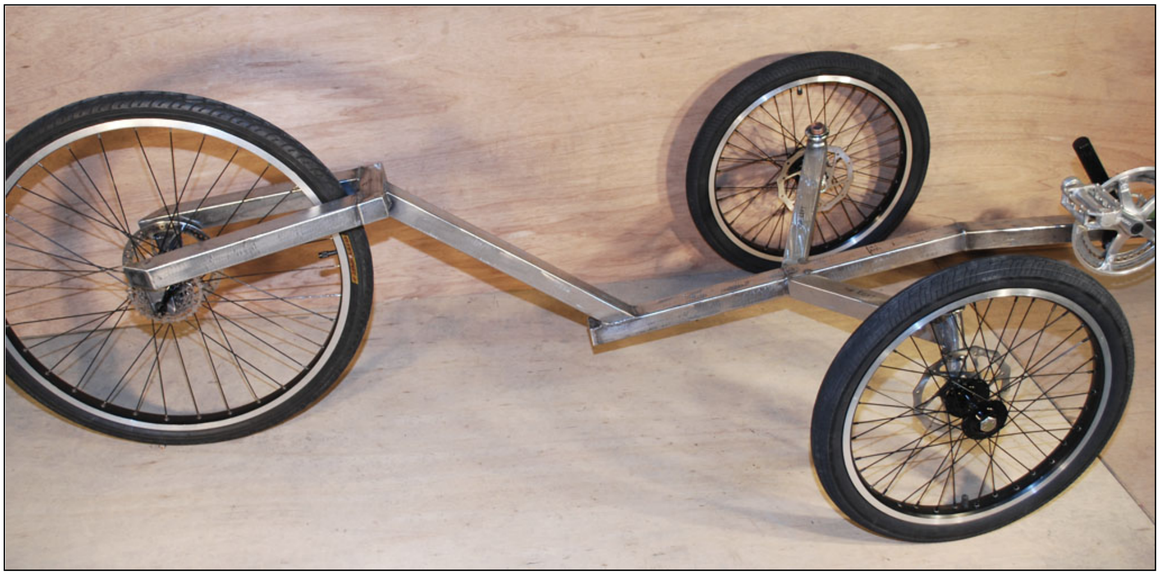

Figure 134 – Checking angle with the wheels installed

The real test of your angles will happen when you have the frame standing on all three wheels as shown in Figure 134. The tack welds need to be on every corner of the boom joints in order to do this, but this is the best way to visually inspect your work as any errors will be obvious. Remove the top fork bearings and tighten down the hardware so that the wheels can be stuck in the perfectly neutral position. The first thing to look at is the rear wheel. Is it leaning? If it is, can you tweak it slightly in the dropouts, or is the frame on an obvious tilt?

A tilted frame will require you to break a set of tack welds on one side of the boom in whatever direction is needed to fix the lean. Another alignment problem will be the front wheels leaning inwards or outwards. This is not a huge problem if it is only a few degrees as long as both wheels are leaning the same amount.

Besides the rear wheel leaning to one side, most other error will probably not be all that noticeable unless your alignment is very far of the specification. I expected to have to break a few tack welds and fix angles, but this time I was lucky. Determination is much more important than luck most of the time!

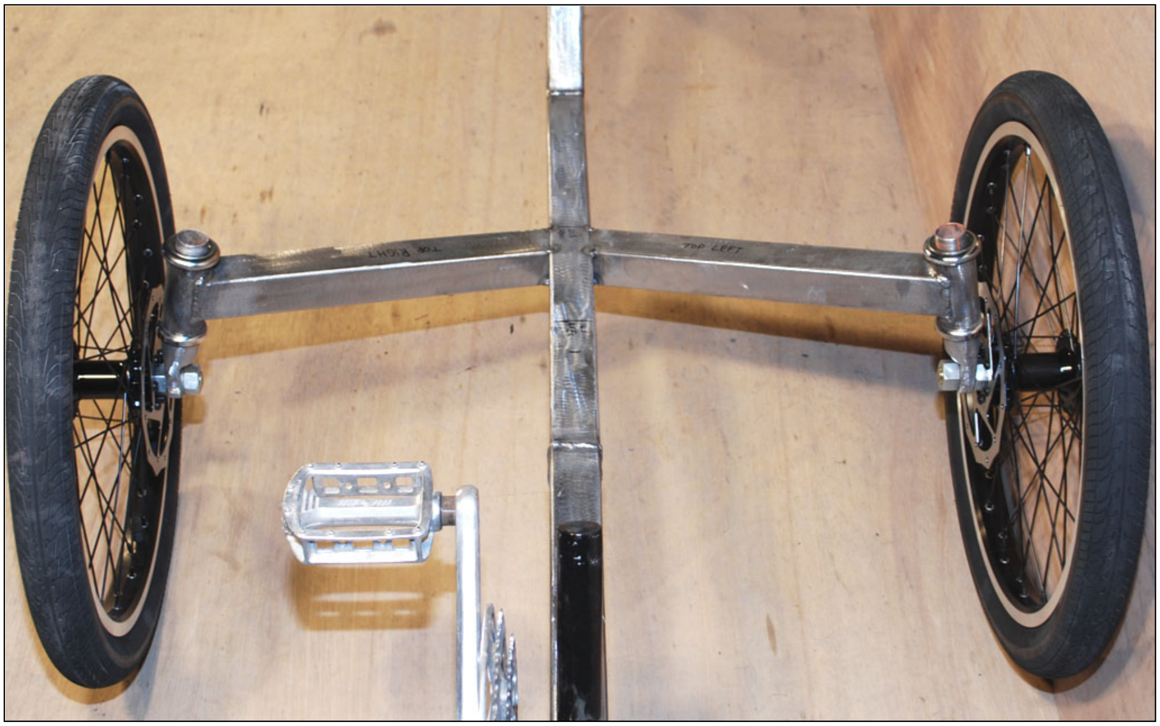

Figure 135 – All three wheels should line up

When looking at your trike from this angle (Figure 135), all three wheels should be standing at 90 degrees to the ground, and there should be no obvious frame leaning or unsymmetrical tubing. To make sure the front wheels are straight, measure the distance between the tiers at the front and back.

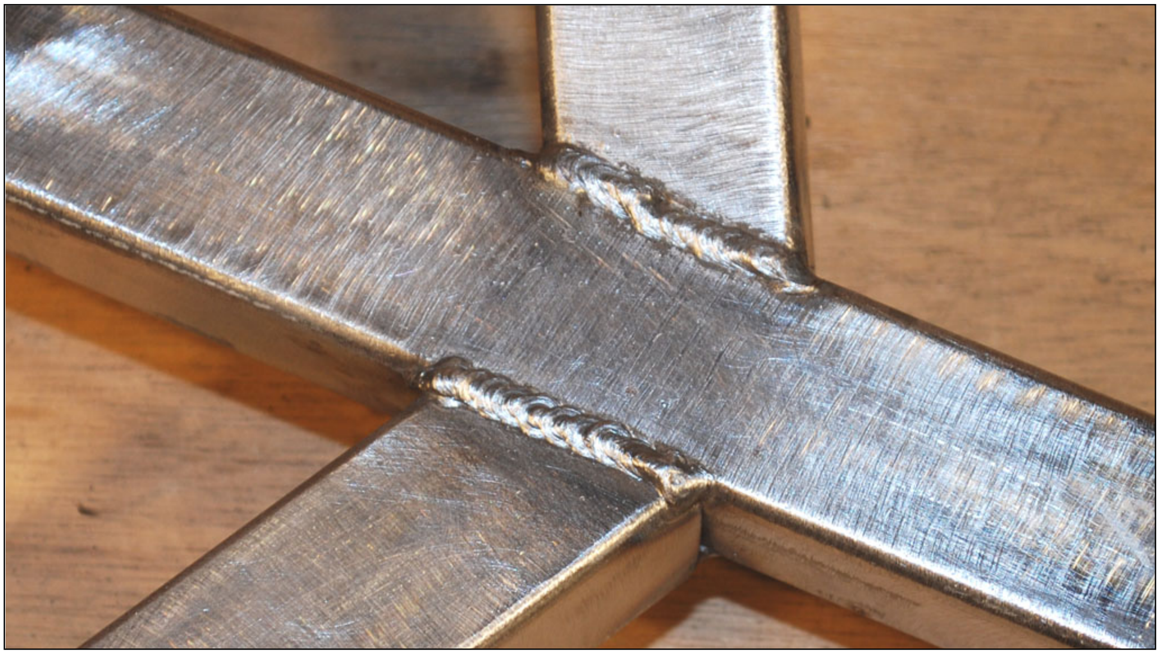

Figure 136 – Committing the steering boom welds

When you are ready to finalize the steering boom welds, start with the top of the joint as shown in Figure 136, making sure the tack welds on the underside are good and solid. Both booms need to be done in the same order so that any slight distortion happens equally to both sides.

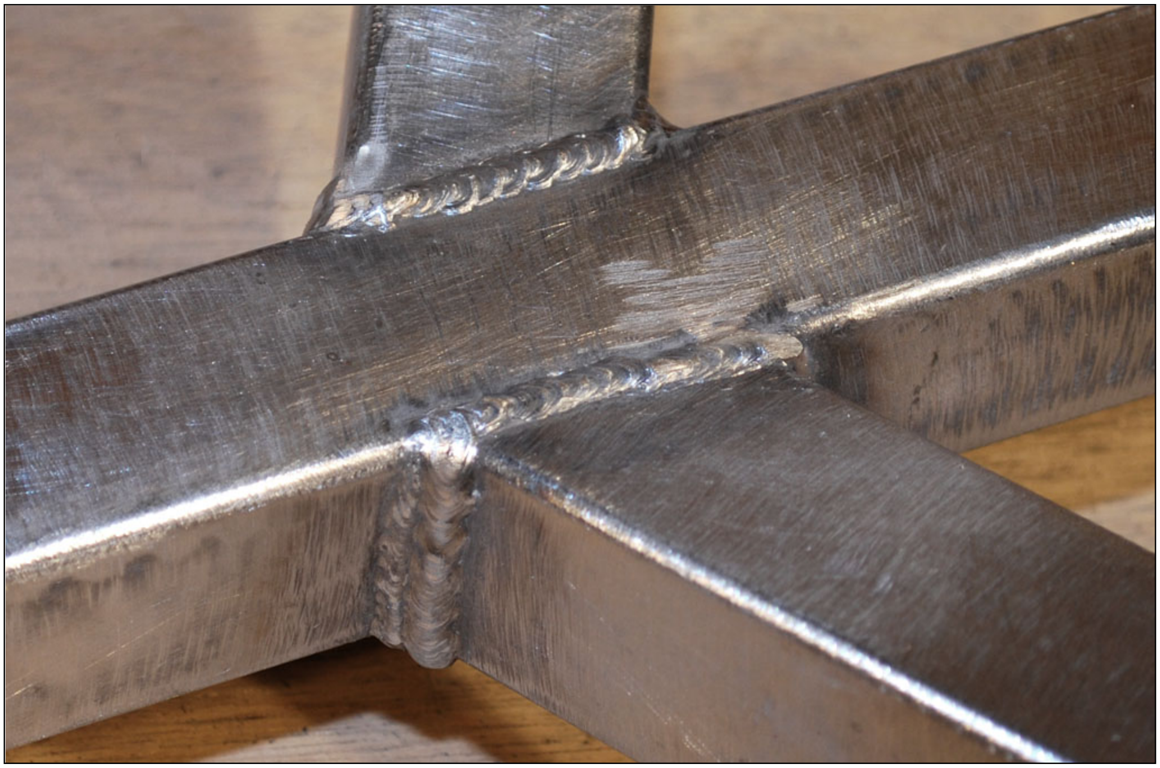

Figure 137 – Welding the front and rear of the joints

The front and rear of the joints are done after the top and bottom as shown in Figure 137. The reason I had to make two passes on this joint is because my guesswork was not perfect when trimming the odd angles on the steering booms, creating a 1/8 inch gap to fill on both sides.

The rest of the build will seem easy now, and there will be no more complex angles or guesstimating to be done.

Under Seat Steering

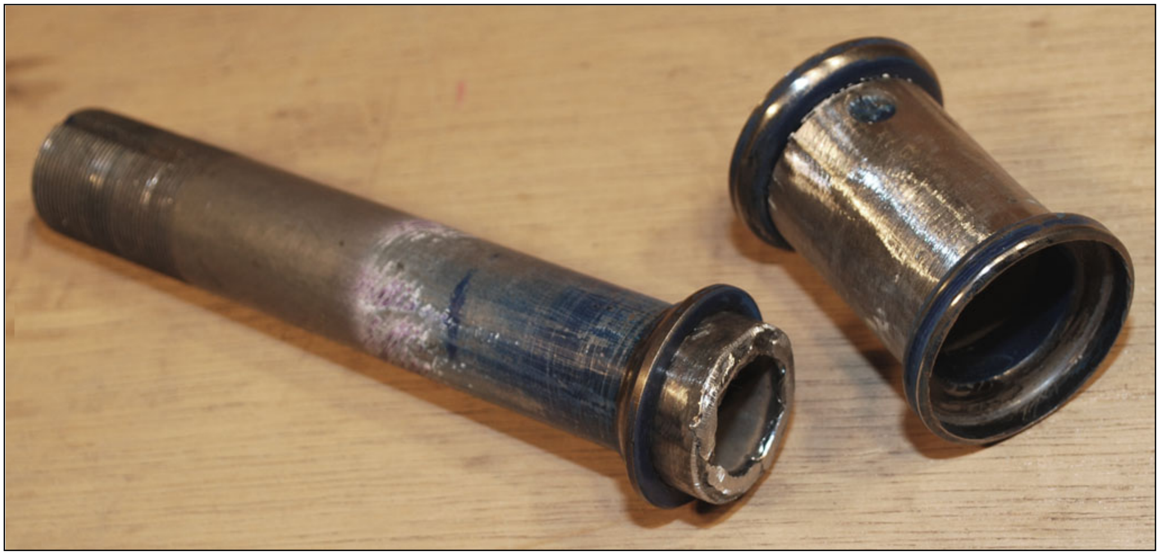

Figure 138 – Parts for the under seat steering

The Warrior has under seat steering, so another head tube and fork stem will need to be miniaturized to fit under the frame. This time, the head tube is taken down to 1.75 inches in length, which leaves just enough room to weld a gooseneck to the shell. Figure 138 shows the shortened head tube and a compatible stem, which will soon be shortened to fit the head tube.

Also, note that the crown has been cut down to half an inch, and that a bead of weld was run around the underside of the crown after cutting it down. This is important because the fork crown is actually made of two tubes fit together, as you can probably see by closer inspection. If you look at the stub you just cut away from the crown, you can see that it was also welded on the base.

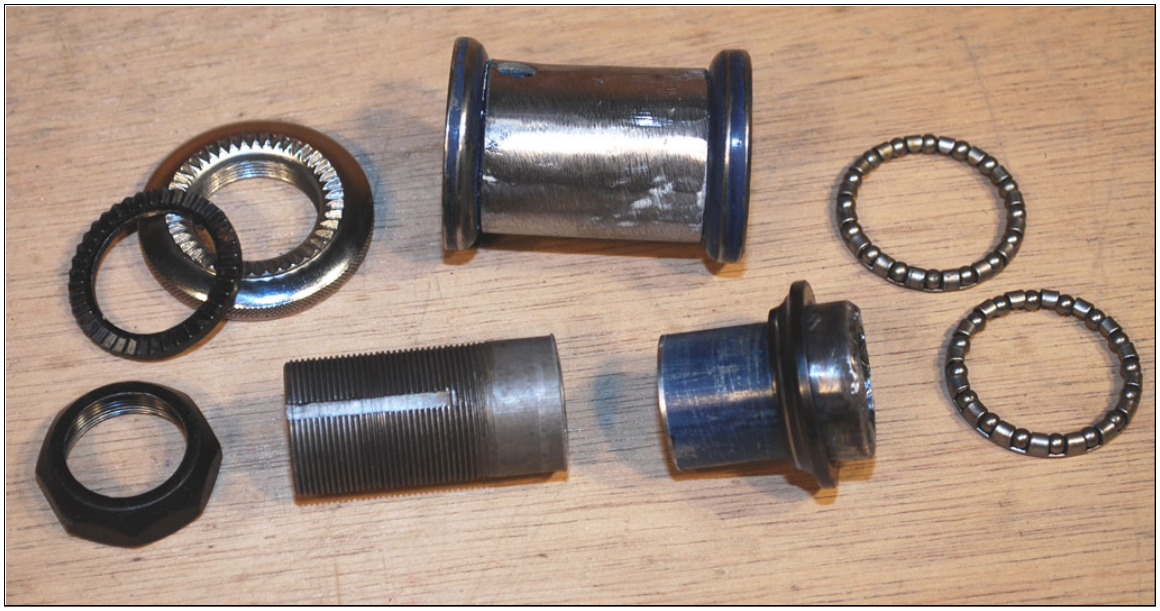

Figure 139 – Shortening the fork stem

Using the same method as shown way back in Figure 97, the fork stem was cut with the pipe cutter so that it would mate with the 1.75 inch long head tube. Figure 129 also shows the rest of the hardware needed to complete the steering system – two bearings, a top race, a locking rind, and the top bolt.

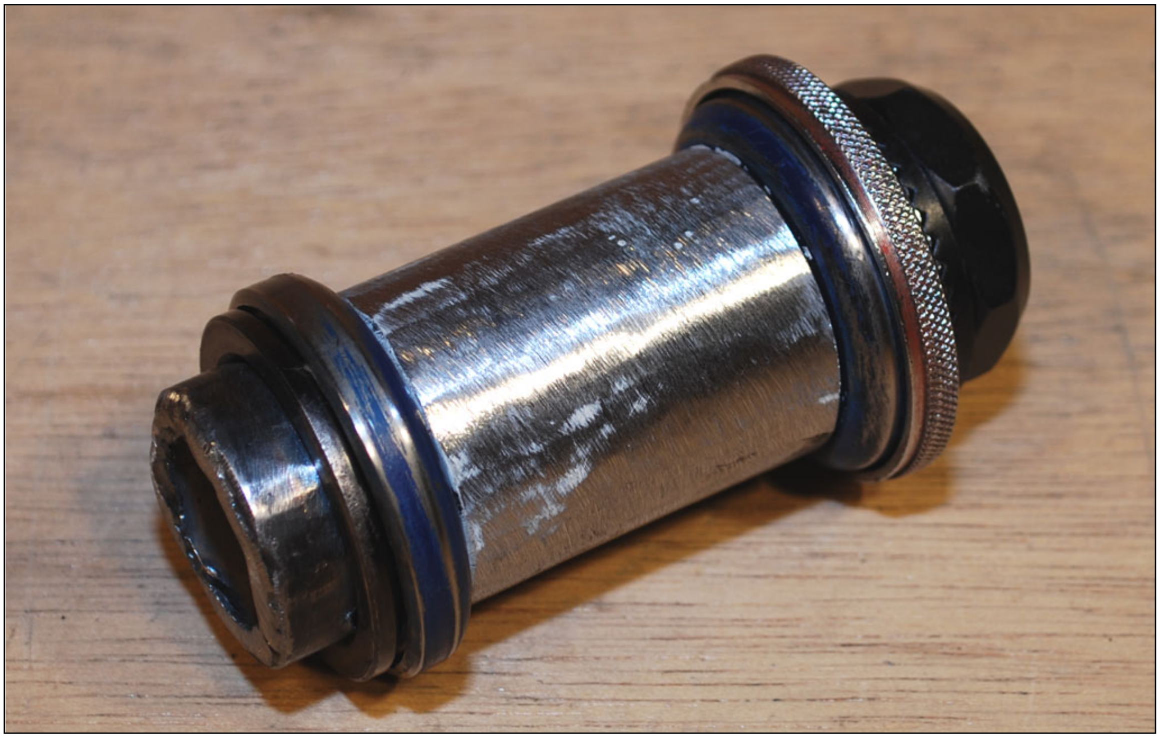

Figure 140 – The miniaturized steering system

The completed mini steering system is shown assembled in Figure 140.

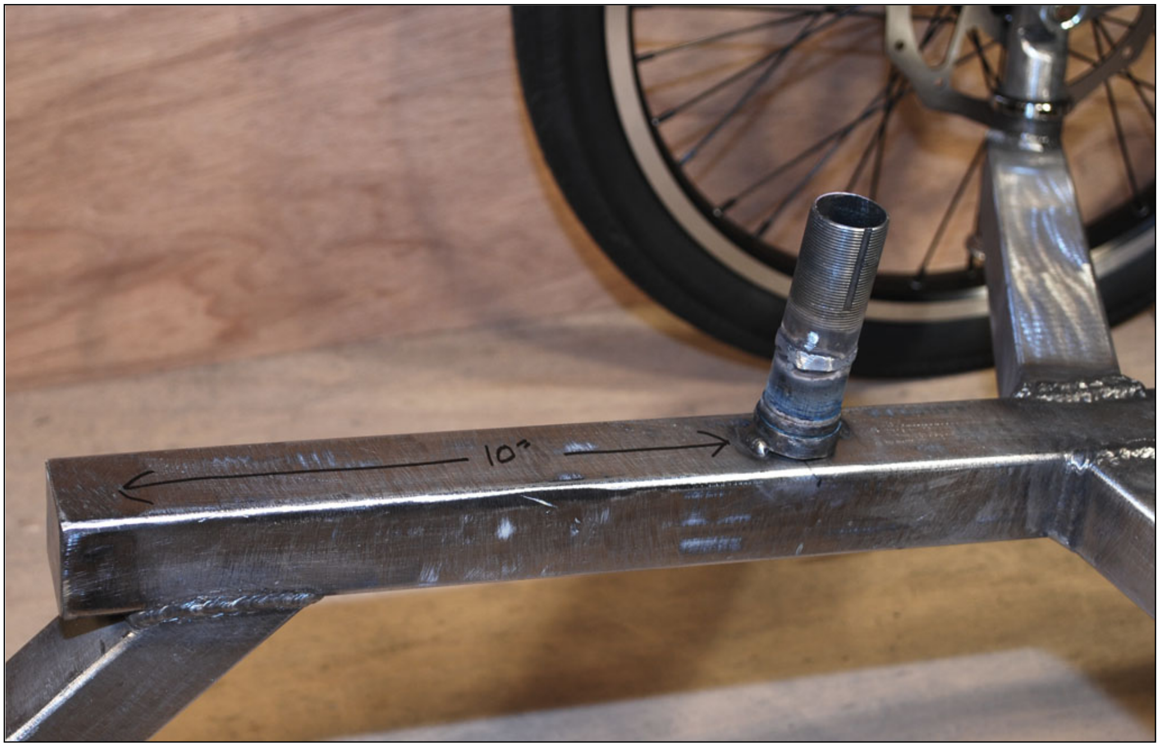

Figure 141 – Positioning the under seat steering system

The under seat steering system will be placed under the frame boom at a distance of 10 inches from the rear end as shown in Figure 140. If you plan on playing around with this measurement, complete the gooseneck and choose your handlebars so you can actually test the feel and position of the handlebars. The dimensions given will be good for most people, but if you think you need more room or have made other modifications, then feel free to try something different. Figure 141 shows the first tack weld made at the fork crown while the bearing race is removed.

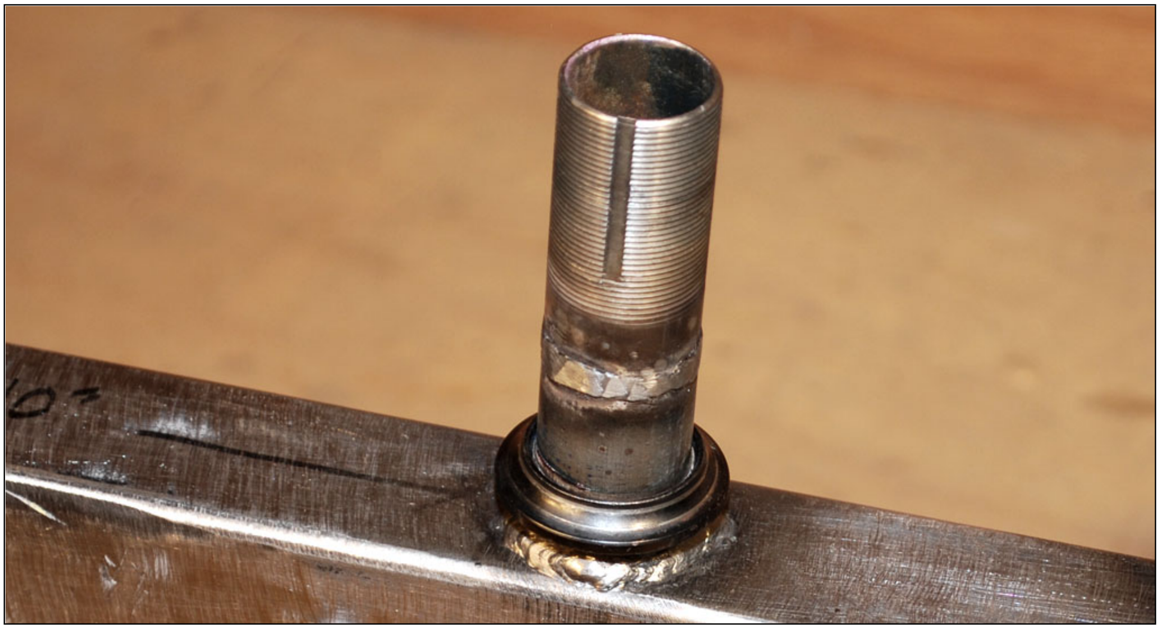

Figure 142 – Fork stem welded to the frame boom

Once you have the fork stem tack welded and aligned with the boom tubing, weld around the entire joint as shown in Figure 142. The orientation of the slot on the stem does not matter, and the bearing race is tapped back on after the part cools.

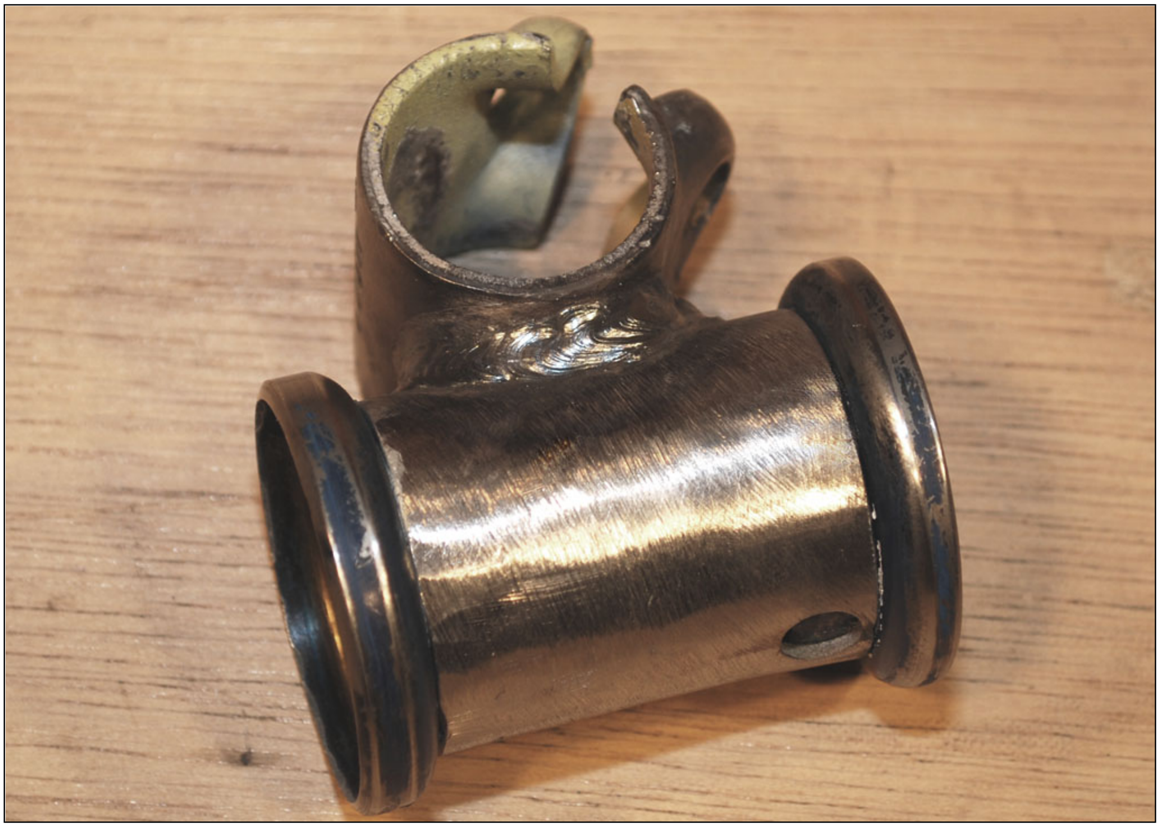

Figure 143 – Adding a gooseneck to the head tube

Although you could also choose to cut a pair of handlebars in half and directly weld them to the head tube shell, adding a gooseneck clamp as shown in Figure 143 allows the alteration of the handlebar angle as well as trying out different type of handlebars. The gooseneck clamp is cut from a standard steel gooseneck so that there is only enough metal left for a weld bead. It must be welded to the head tube so that the handlebars will be perfectly parallel to the ground.

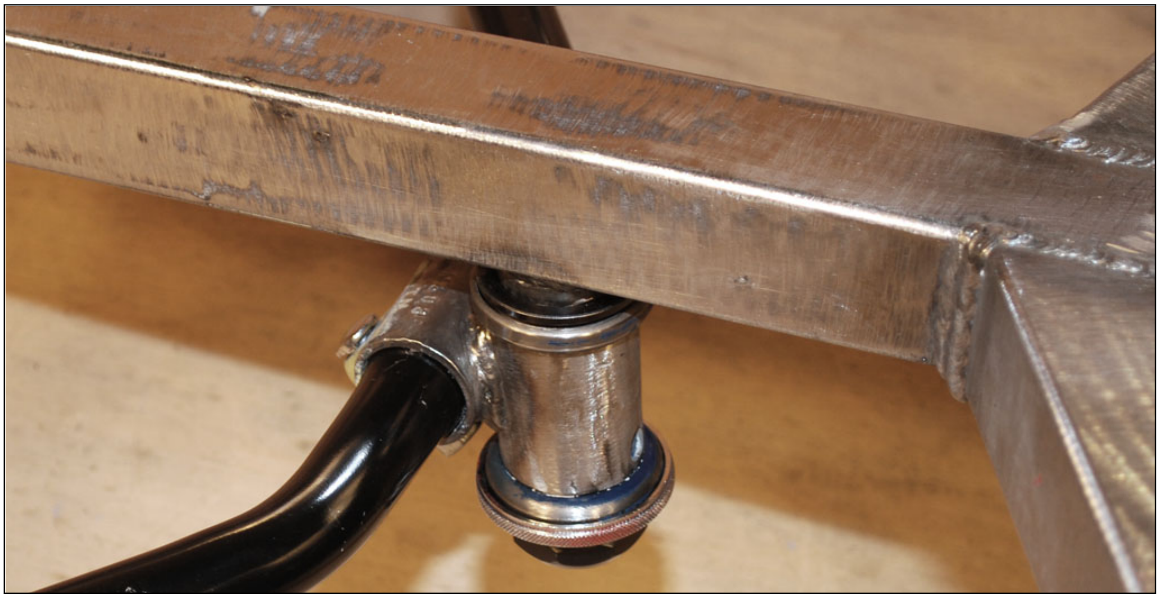

Figure 144 – Handlebars installed

When welding the gooseneck to the head tube shell, it helps to make a solid tack weld on the gooseneck joint, and then install handlebars so you can check the alignment of the gooseneck clamp. Figure 114 shows a pair of handlebars installed on the completed under seat steering assembly.

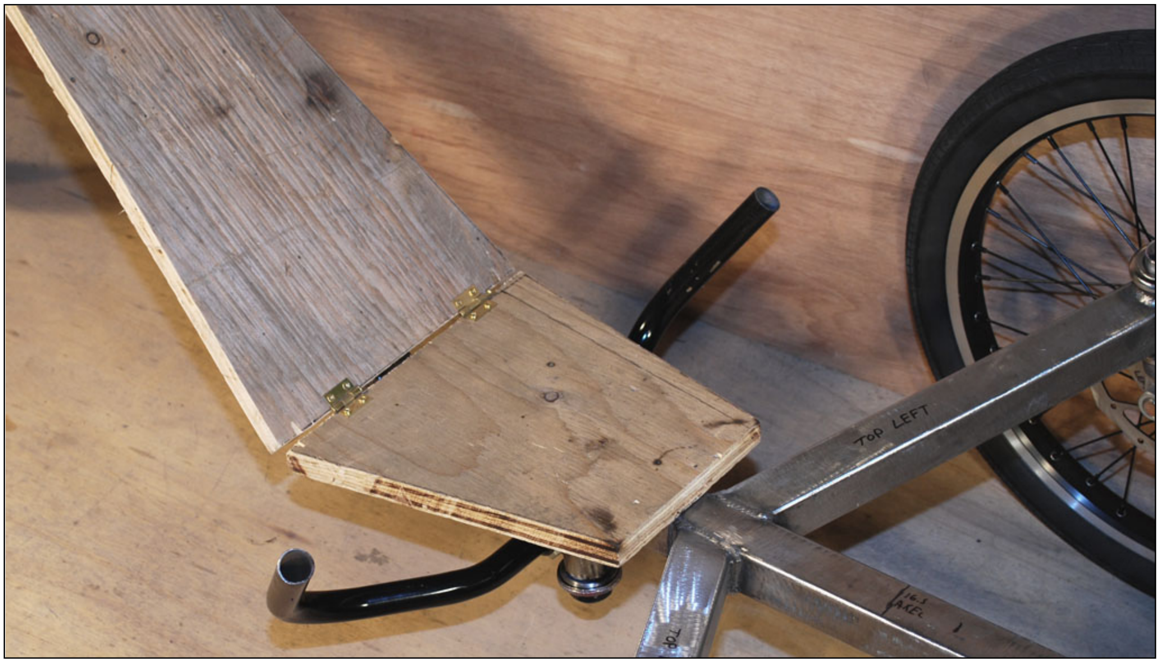

Figure 145 – Choosing the best handlebars

The choices for handlebars are almost endless, so you may need to try a few styles out to find out which ones feel the most comfortable. Sit in the seat and let your hands drop to your sides – this is probably the best position for your wrists. The “granny bike” style handlebars shown in Figure 145 seem perfect for this type of under seat steering, and offer plenty of turning radius before hitting the frame or seat boards. You can also make your own handlebars by cutting and joining multiple handlebars or by using a tube bender to bend some ¾ inch conduit or tubing.

If you do join multiple handlebars, ensure that the welds are done correctly, as you want to have a solid structure to hang on to when blasting into corners. Next, we will make identical brake support tubes.

Make Brake Support Tubes

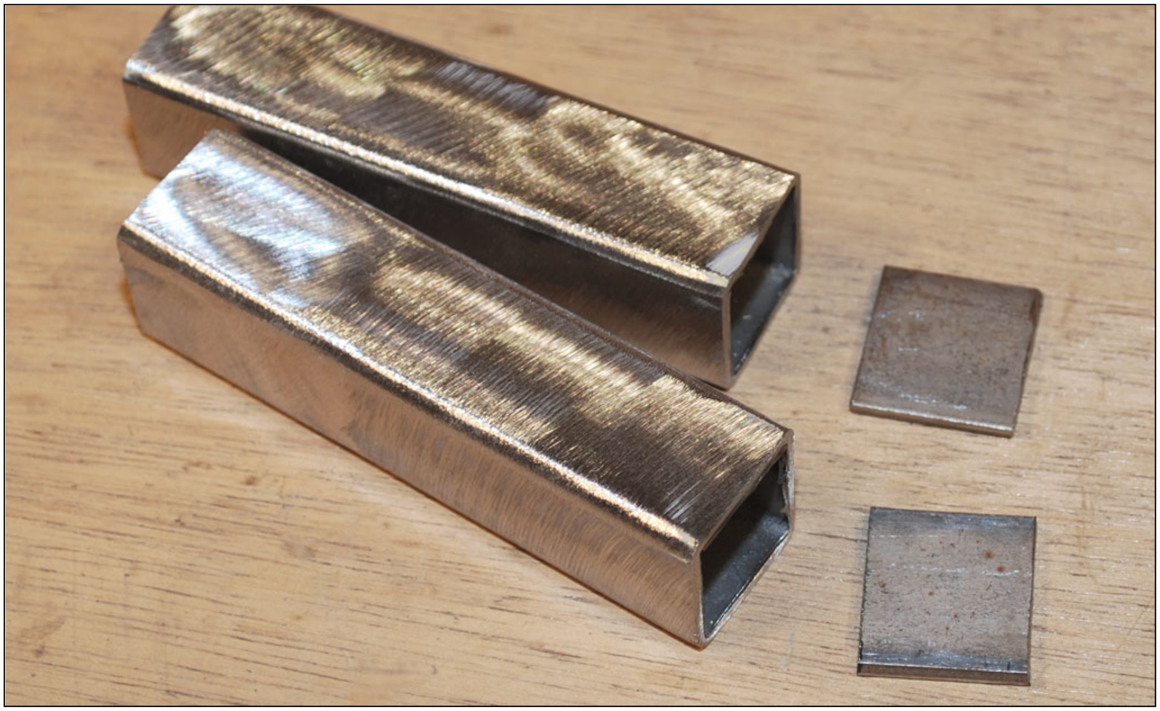

Figure 146 – Cutting the brake support tubes

The Warrior offers multiple options for brakes, with two front disc brakes being the most common configuration for tadpole trikes. You could also run a third rear disc brake, but besides the ability to skid out around corners, having two front brakes is plenty of stopping power for your trike, and will not require any fancy cable splitters or dual action levers. Remember that three brakes into two levers is a bit of an odd setup. Requiring a small component called a cables splitter than allows pulling two cables with one lever. You can also find dual cable brake levers online with a bit of searching. I like the rear skid factor, so I added the rear disc brake as well!

The brake support tubes are ¾ inch square tubes with a wall thickness of no less than 1/16 inch (16 gauge). They are cut to a length of 4.25 inches.

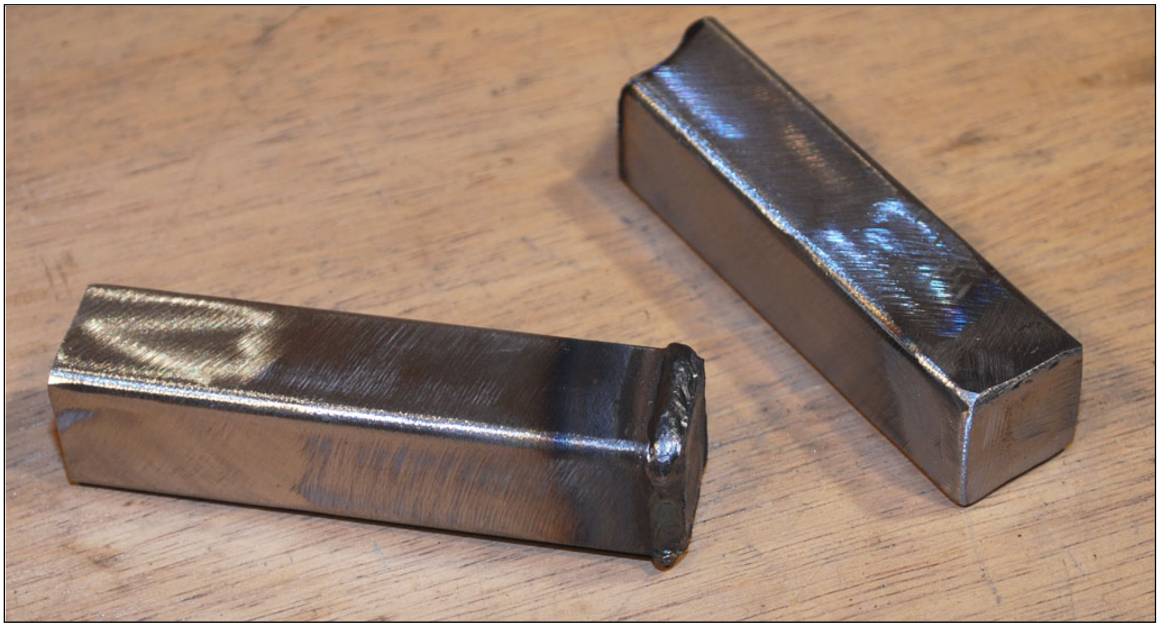

Figure 147 – Capping and grinding the brake tubes

The brake support tubes must be welded to the fork crown and steering tabs as shown in the next few photos, so one end will get a cap (Figure 147), while the other end must be ground so conform to the fork crown.

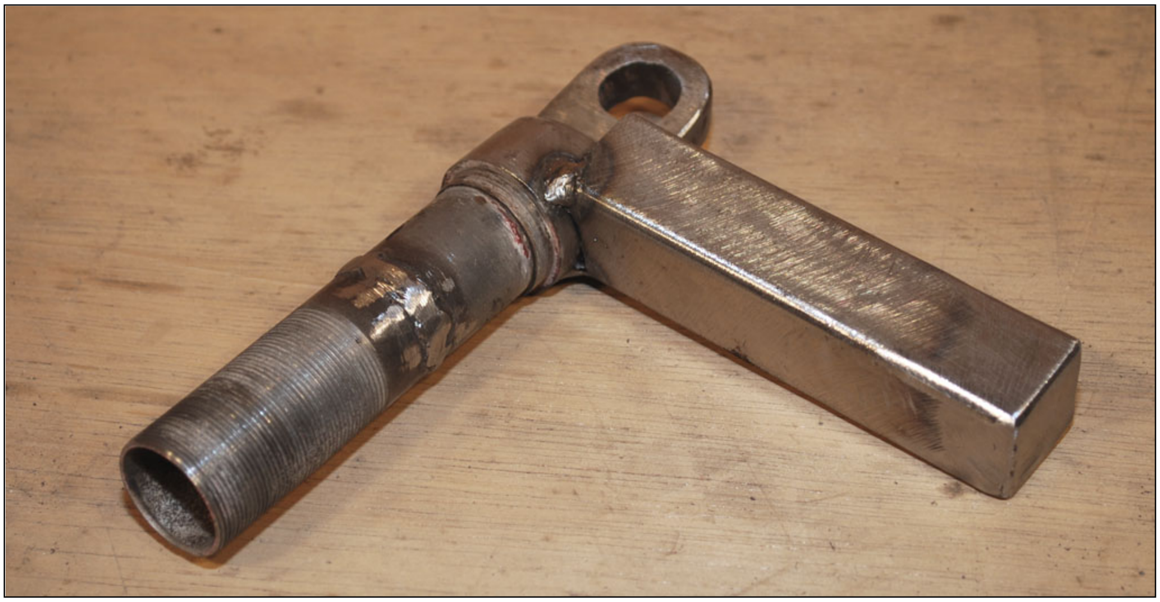

Figure 148 – Tack welding the brake support tubes

The brake support tubes form a 90 degree angle with the fork stem as well as being perfectly inline with the axle support tab so they are parallel with the disc brake rotors (see Figure 149). As shown in Figure 148, when the part is laid flat, the axle tab and brake support tube will be parallel to the ground. First, tack weld the tubing, so you can fine tune the angles while using the disc brake rotor as an alignment guide.

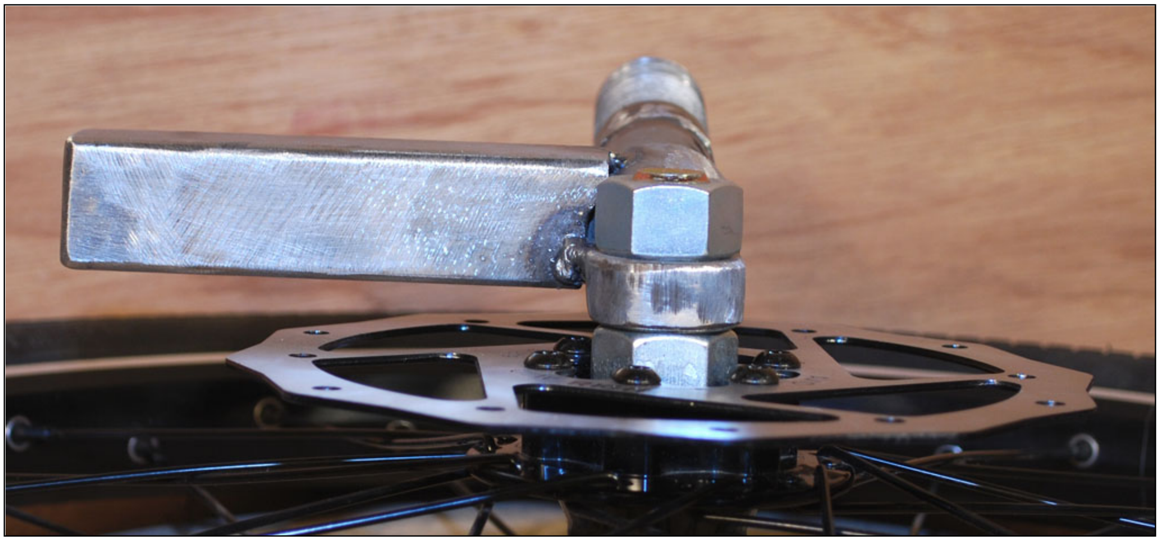

Figure 149 – Checking brake rotor alignment

Try to get the brake support tubes as parallel to the brake rotors as you can as shown in Figure 149. Also, keep in mind that there will be a right and left side, and that the brake support tubes face towards the rear of the trike.

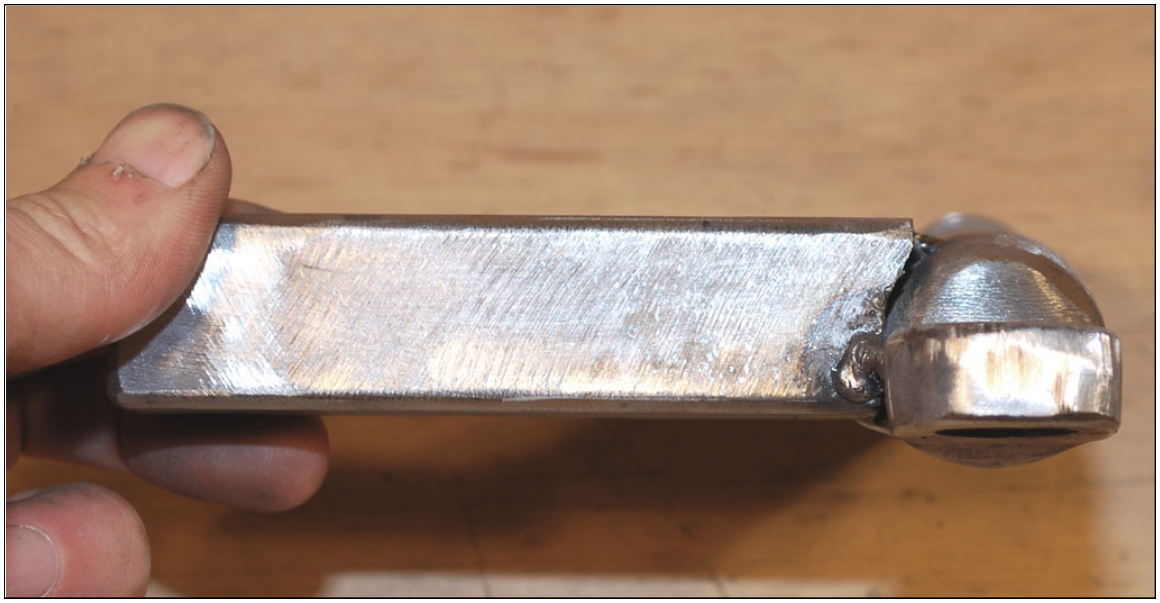

Figure 150 – Checking alignment with the axle tab

If you place a straight edge on the axle tab, it should line up with the brake support tube. Figure 150 shows the bottom view as well as the somewhat rounded cut made to conform to the fork crown before welding.

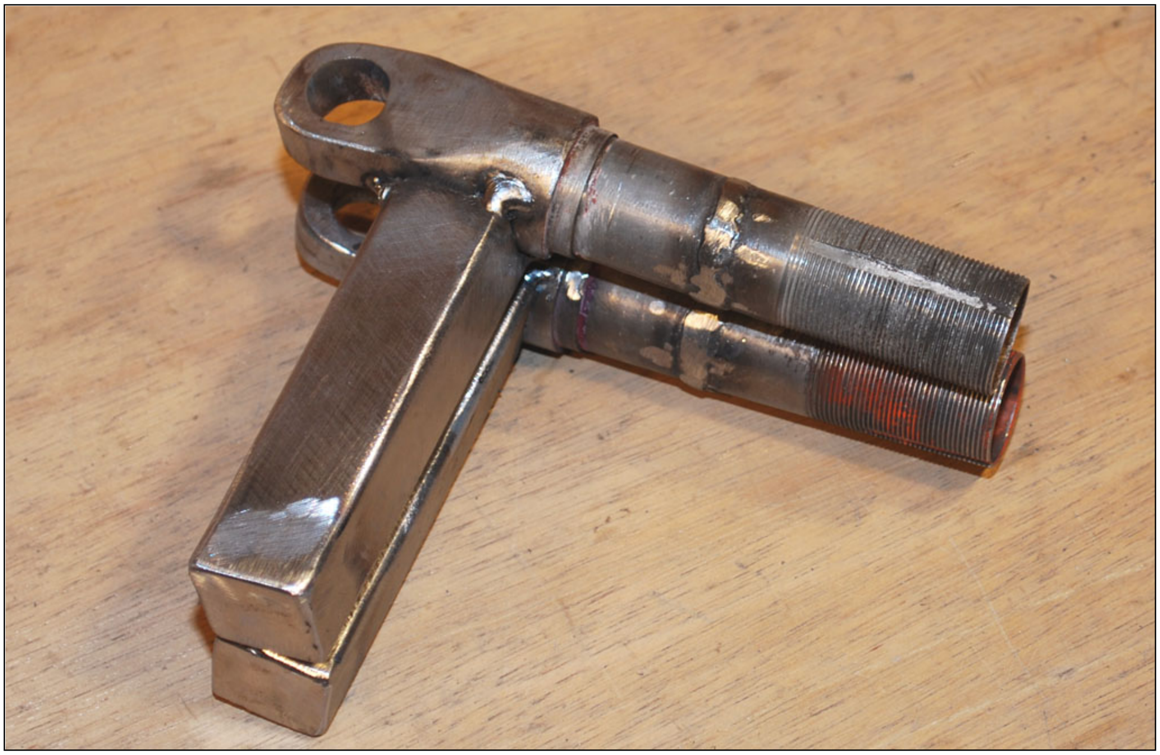

Figure 151 – Making sure both parts are equal

The brake support tubes also serve as a mounting base for the steering components, so you want to ensure that both parts are equal (mirrors of each other). As shown in figure 151, both parts should line up perfectly, and the axle tabs will be angled opposite to each other, creating a mirrored pair.

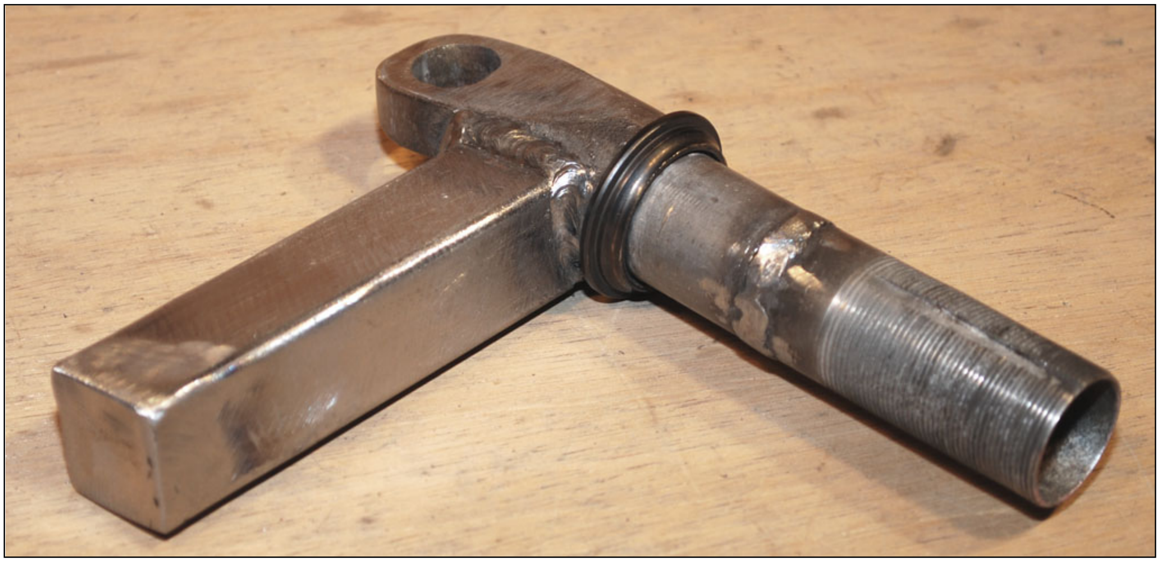

Figure 152 – Completing the brake tube welds

Once you have checked the alignment of the two brake support tubes against each other and the disc rotor, weld around the entire joint as shown in Figure 152, making sure that the welds are decent with no pits or gaps. There is a lot more force involved in braking than there is in acceleration, so this little tube is going to see a lot of stress, especially if you ever have to lock up the wheels on pavement. Next, we will make the steering control arms and discuss Ackerman steering principles.

Make Steering Control Arms

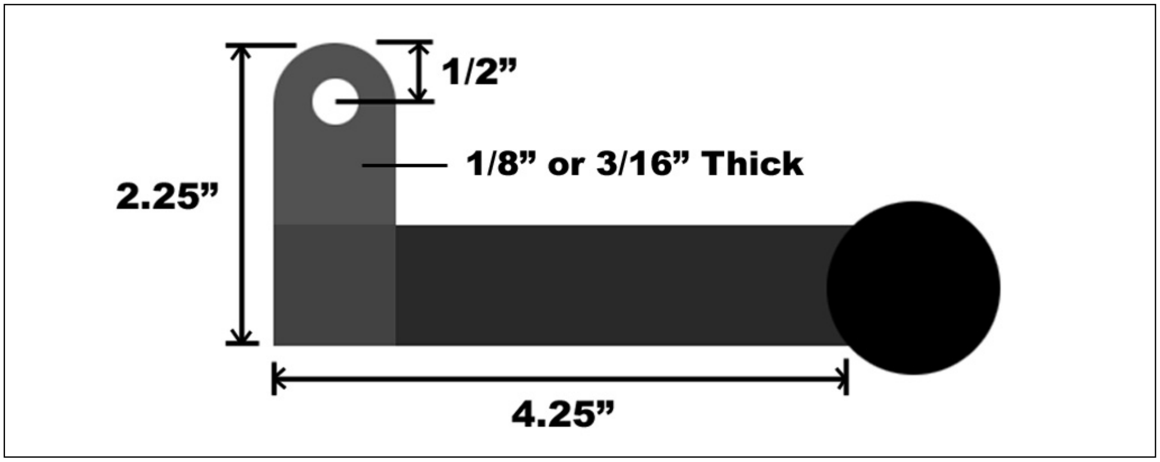

Diagram 7 – Steering tabs and brake tubes

The steering linkage on the Warrior Trike takes care of several design challenges such as Ackerman steering and proportional steering between the wheels and handlebars. Ackerman steering defines a system of steering that allows the wheel on the inside of a turn to have a much sharper angle than the wheel on the outside of the turn.

If you imagine a trike making a non-stop circle, it is obvious that the wheel on the inside of a turn has to travel less distance than the outer wheel due to the circumference of the circular track being smaller. Although this sounds like a huge engineering problem, it is not so bad, and already taken care of for you by following the dimensions shown in Diagram 7 when you install the steering control arms on the brake support tubes.

The dimensions are important in order to achieve proper Ackerman steering geometry, so cut the control arms to the specified length, make sure the hole is in the correct place, and your trike will steer perfectly without any wheel scrubbing around corners. Wheel scrub occurs when Ackerman geometry goes bad, and will not only steal away your energy, it will wear your tires down to nothing in a hurry of you drive on pavement with many corners a lot.

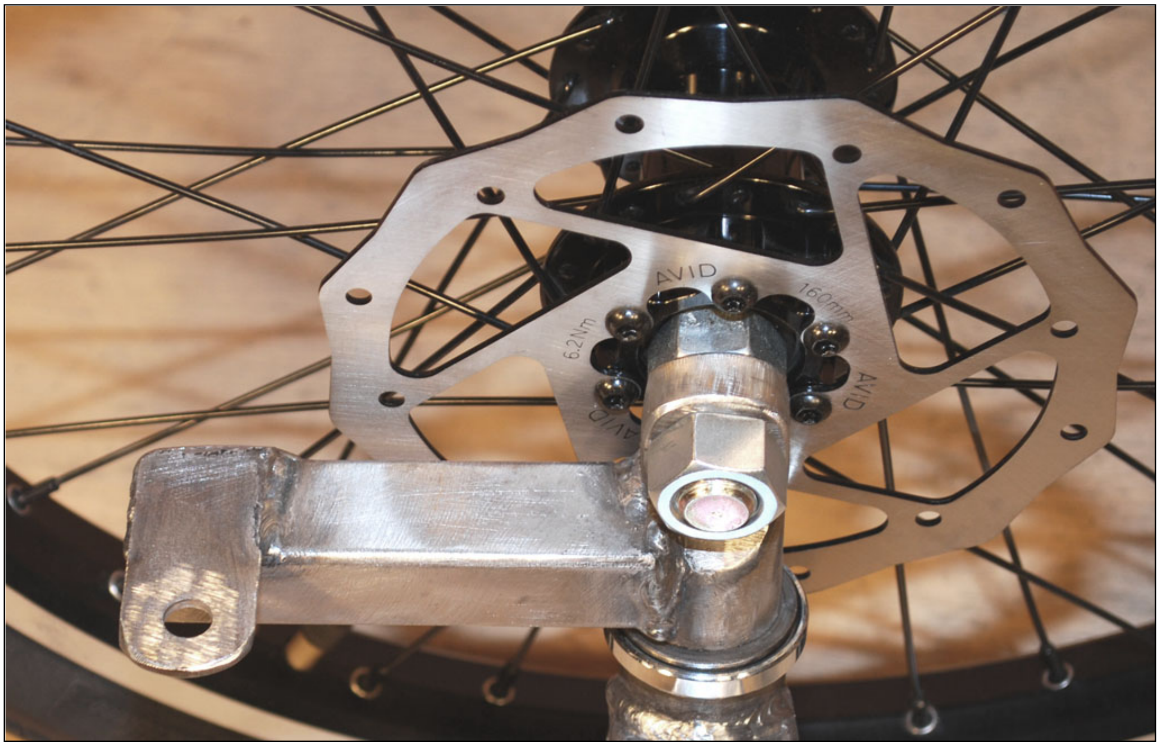

Figure 153 – Adding the steering control arms

The two front steering control arms are added to the brake support tubes as per Diagram 7. Of course, there is always a right and left side, and the steering control arms face inwards towards each other so they can link together later. Figure 153 shows how the control arms are welded to the underside of the brake support tubes, using the edges as a guide.

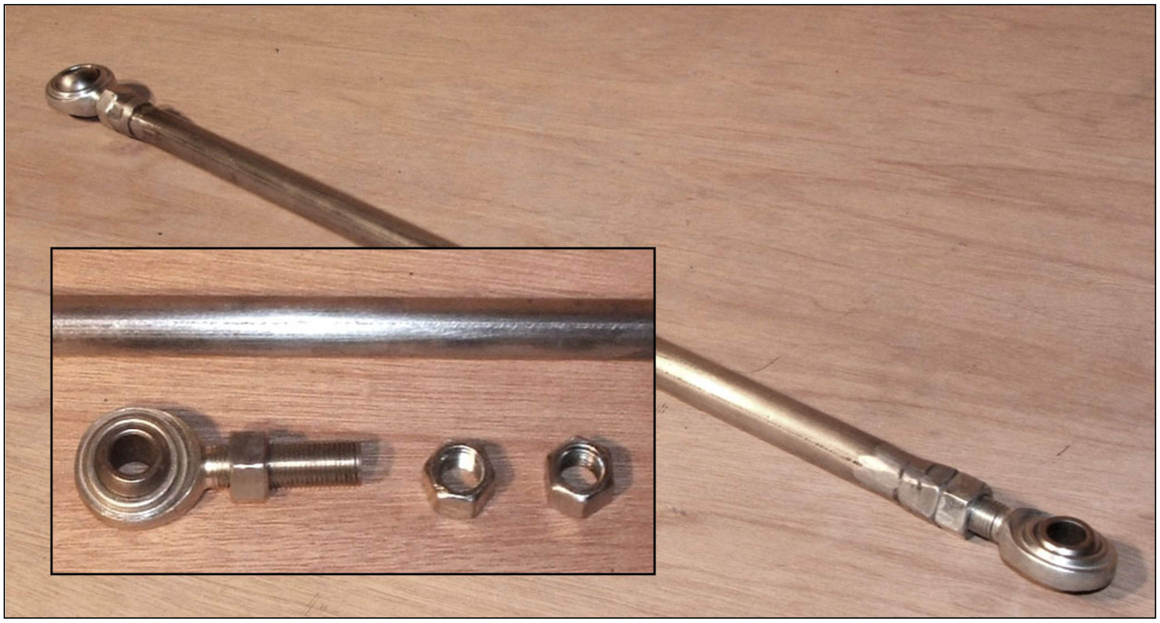

Figure 154 – Adding the steering control arms

The two steering control arms are linked together by a control rode with two ball joints (a spherical bearings) at each end. The steering on the Warrior trike is identical in many ways to the steering geometry of an automobile, and the linking of wheels is no different. A control rod made of some hollow ½ inch tubing will have a pair of ball joints mounted at each end so that the two front control arms are linked together. Figure 154 shows how one bolt is welded to the control rod so that the ball joints can be adjusted an inch or so at each end to set up the steering for perfect alignment later.

The ball joins or aspherical bearings are rated by their bolt hole size, and the ones I always use are made for a 3/8 bolt, and include a bolt body so that they can screw into the net welded at the end of the rod. It’s easy to figure out how long to make the rod by installing all three wheels and then by rolling the trike forward. As the trike rolls forward, the two front wheels will magically fall into perfect alignment after a few feet due to the steering geometry.

Stop the trike, wedge the rear wheel so it does not move anymore, and then carefully pull a tape measure between the bolt holes on the two control arms. This hole-to-hole distance is what you are shooting for on your control rod (between the holes of the ball joints to match). Allow about half an inch of alignment room either way, so if your control arm hole-to-hole distance is 21.5 inches (mine was), then build your connecting rod so that you can screw the ball joint in to about 20 inches, or back them out to about 22 inches. This will help set up alignment after your trike is completed.

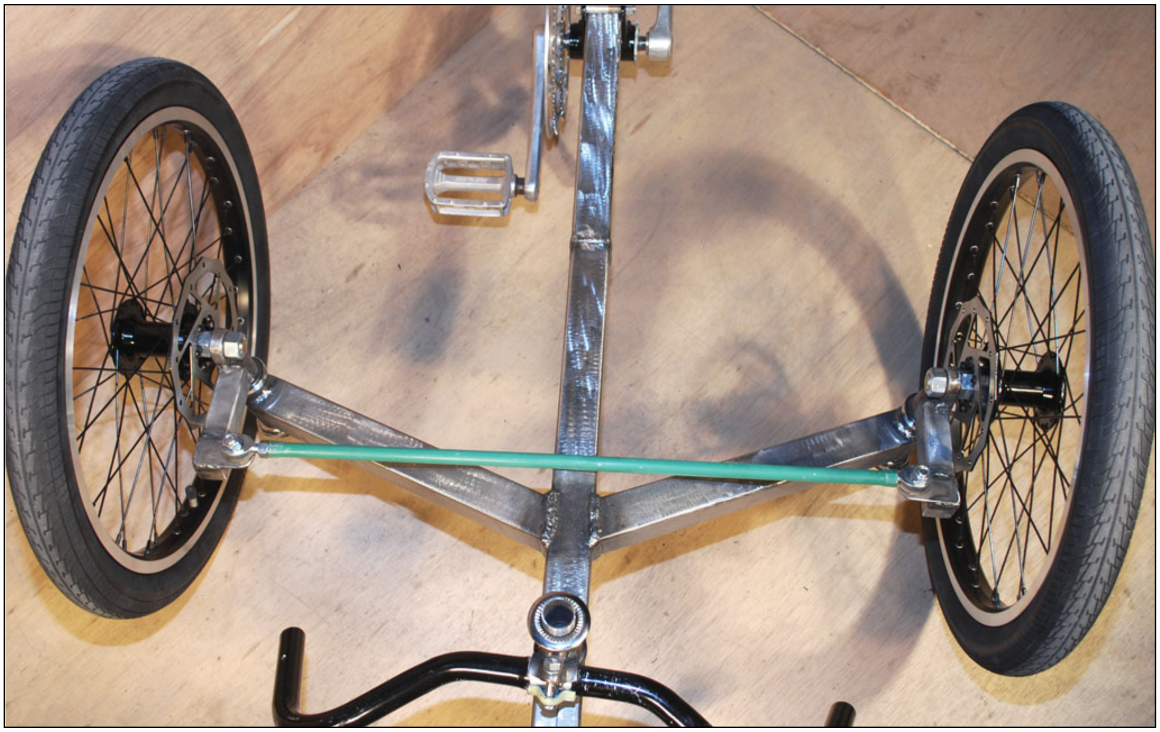

Figure 155 – Control rod linking the two front wheels

The completed main control rod is shown in Figure 155, linking the two front wheels after figuring out the correct hole to hole measurements. Actually, this control arm was taken from another trike I built called the StreetFox, and because the steering on the Warrior is based on it, the length was already correct, which is why it is shown painted.

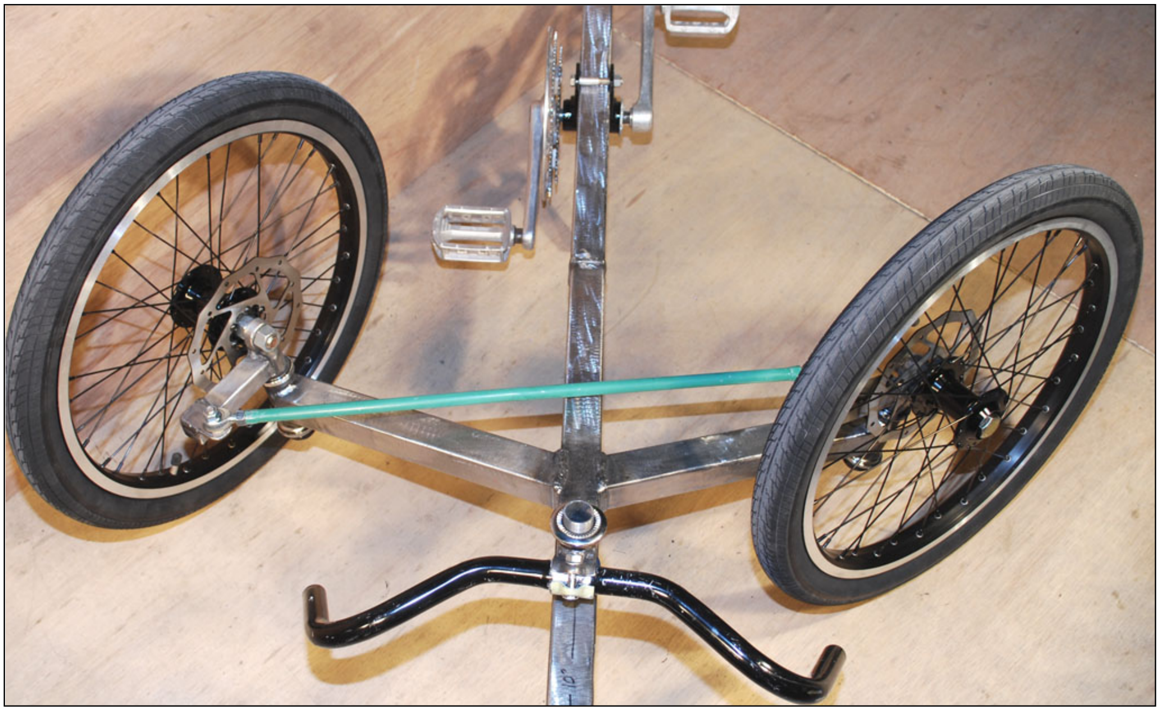

Figure 156 – Demonstrating Ackerman steering angles

When you turn one of the wheels towards the cranks to about 45 degrees, you will notice the other wheel making a much tighter turn until it literally locks out and hits the frame. This non-proportional steering is the magic of Ackerman geometry at work, compensating for the inner turning circle being small than the outer circle. If you roll your trike around the floor, making turns, you will notice that neither wheel drags at all in the corners until you start getting into turning angles that are way beyond what will be the limits once the seat and other steering components are mounted.

Also, note that if your ball joints seem to rub on the control arms a lot, you can make a spacer by either drilling out a small diameter washer so the hole fits your ball joint bolt hole, or by taking a nut and grinding it down so that it is about half as tall as it used to be. Some ball joints have thicker bodies, so as the control arms turn option an angle, some rubbing may occur. I had to use the ground down bolt space method on my steering system to avoid rubbing.

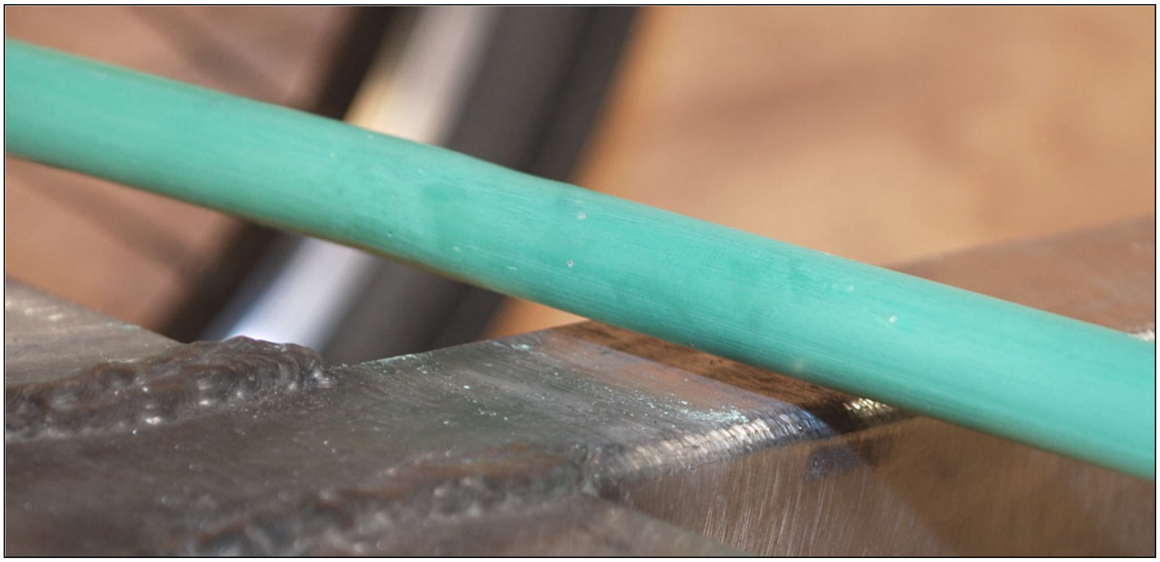

Figure 157 – Control arm clearance should be tight

Another reason you might need the ball joint spaced between the ball joint and control arms is because the control arm will be very close to the frame boom as shown in Figure 157. It should be as close as possible, though, to allow for turns up to about 40 degrees, but not rub on the frame. Spacers may be necessary.

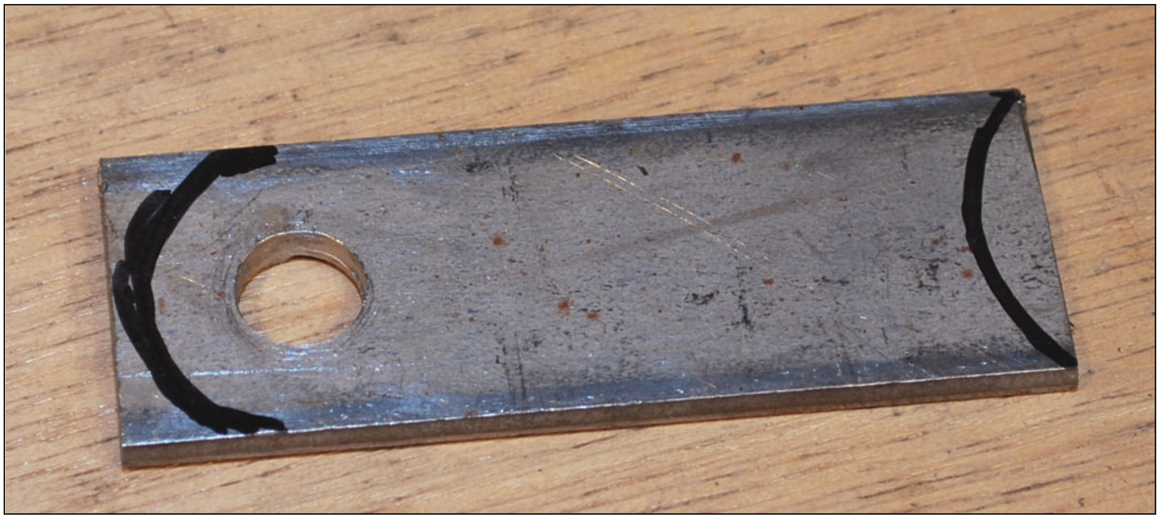

Figure 158 – Making the pilot’s steering control arm

The under seat steering system must link up to the front steering system using two more control arms and another control rod. This control arm is made the same way as the steering control arms, but is 3 inches in length, rather than only 2.25 inches. The rounded area traced in Figure 158 is to conform to the head tube shell where it is to be welded. Read ahead up to Figure 165 so you can understand the angles and tight clearances that are needed for the rest of the steering parts before doing any more welding. The mechanical bits get pretty tight under the seat, so a little tweaking might be needed to avoid interference problems between the hardware.

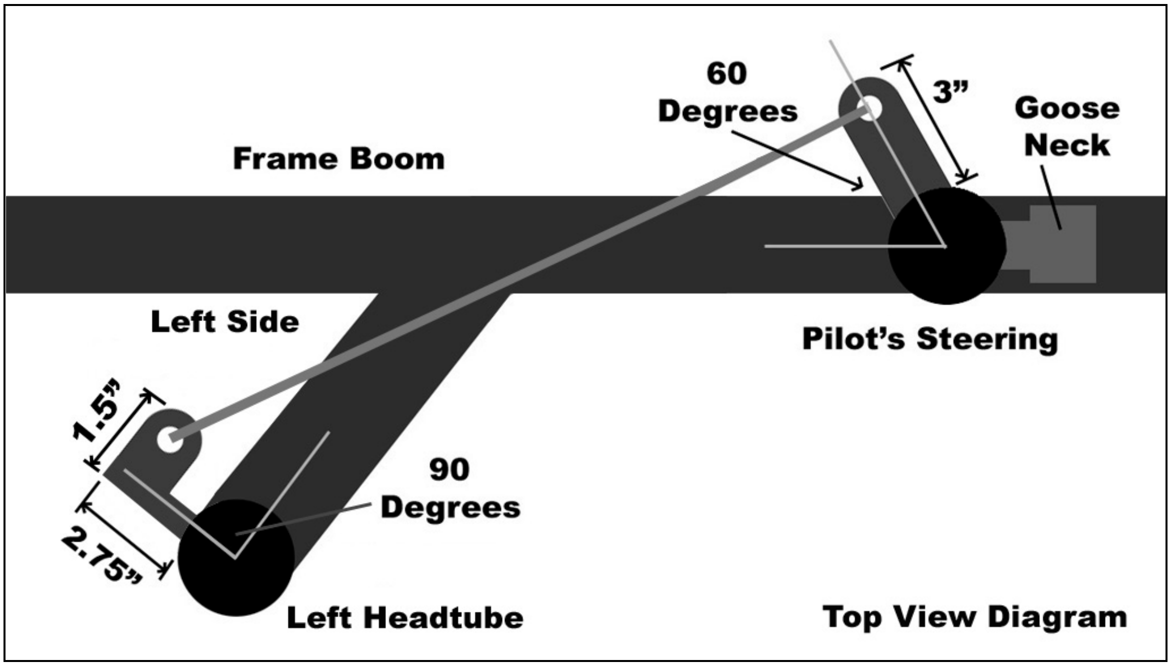

Diagram 8 – Pilot’s control arm angles (not to scale)

When I was designing the steering for the Warrior Trike, I noticed that the pilot’s control arm and the mating control arm on the right wheel hardware had to be at odd angles in order to have proportional steering. Proportional steering means that the wheels turn left or right the same amount as the handlebars turn left or right. Without these odd angles, the wheels would turn a lot faster or have a very limited range of motion on either the left or right side. The angles shown in Diagram 8 took a lot of trial and error to figure out, but work perfectly. If your frame dimensions are different than mine, you may have to do some of your own trial and error to get good proportional steering.

The angles of concern are between the left side control arm and the steering boom (90 degrees) as well as between the pilot’s control arm and the frame boom (60 degrees). A few degrees out either way will not make a huge difference, but try to get them as close as you can.

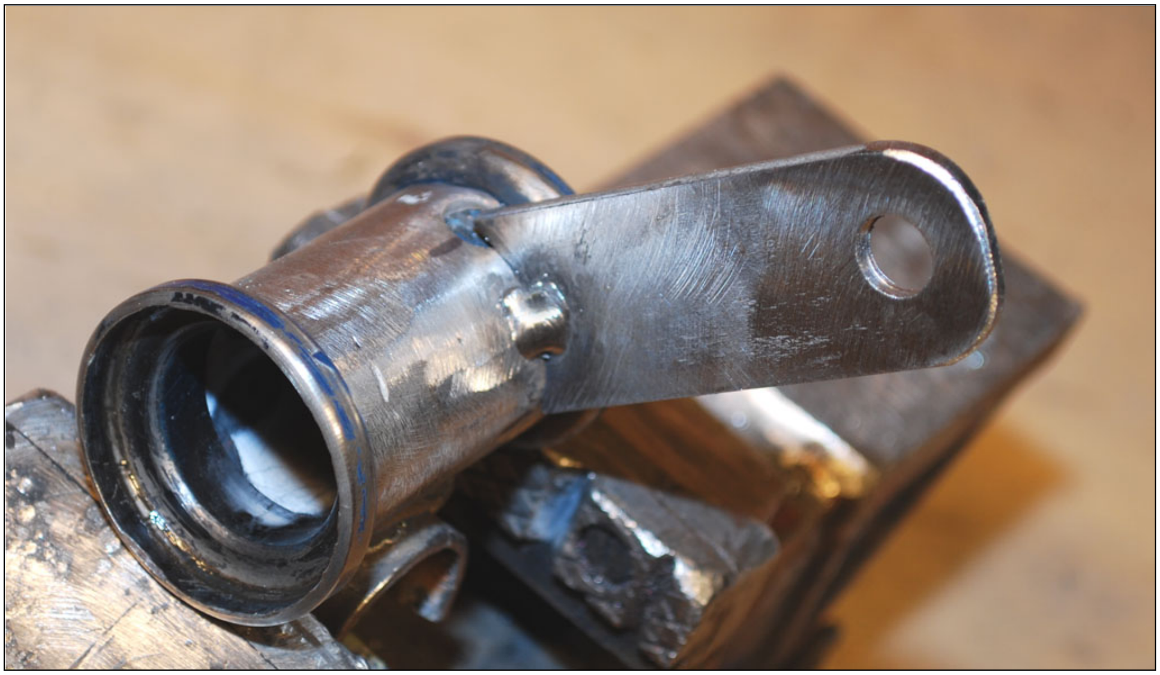

Figure 159 – Installing the Pilot’s control arm

The pilot’s control arm makes a 60 degree angle between the main frame boom and the gooseneck is on the other side as shown in Diagram 8. Also, note that the control arm must be placed as high up on the head tube as possible to allow clearance for the rods to cross. This can be seen in Figure 162,164 and 165. It may be a good idea to just use good tack welds at first until you have had the chance to test your steering system with all of the hardware installed. I did this about 30 times when I was originally figuring out the best angles!

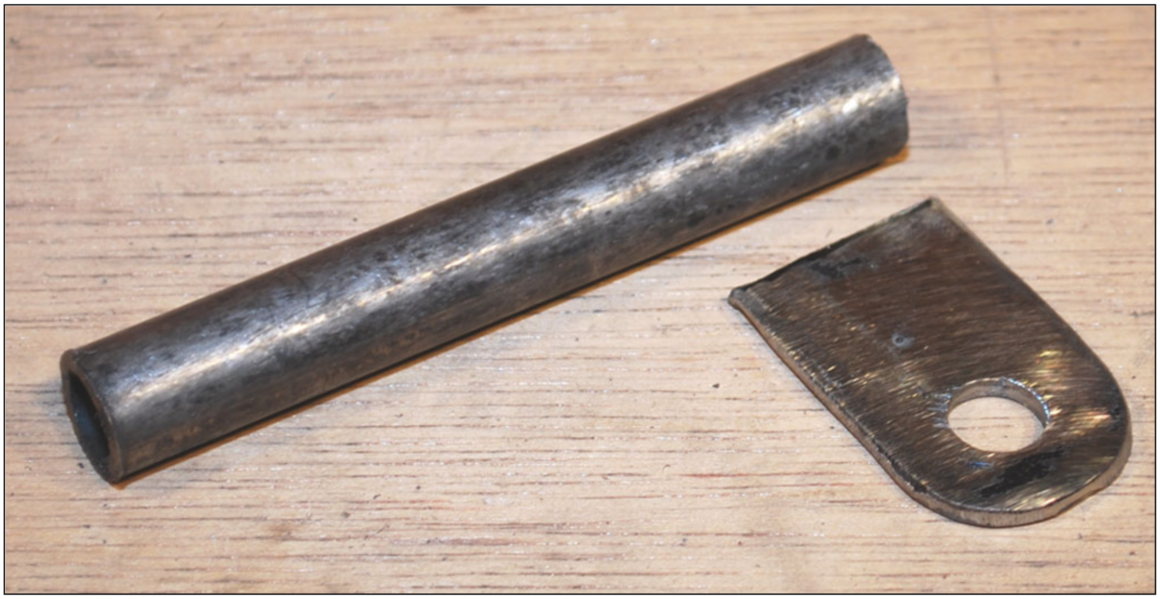

Figure 160 – Making the right wheel control arm

The left wheel control arm is 2.75 inches long, which gives the steering some mechanical distance advantage because the pilot’s control arm is slightly longer (3 inches). The small tube is just a 2.75 inch length of half inch hollow rod, or it can be solid, or even a length of cut away bolt. The 1.5 inch long tab is made the same way as the other control arms, and will be welded to the rod as per Diagram 8.

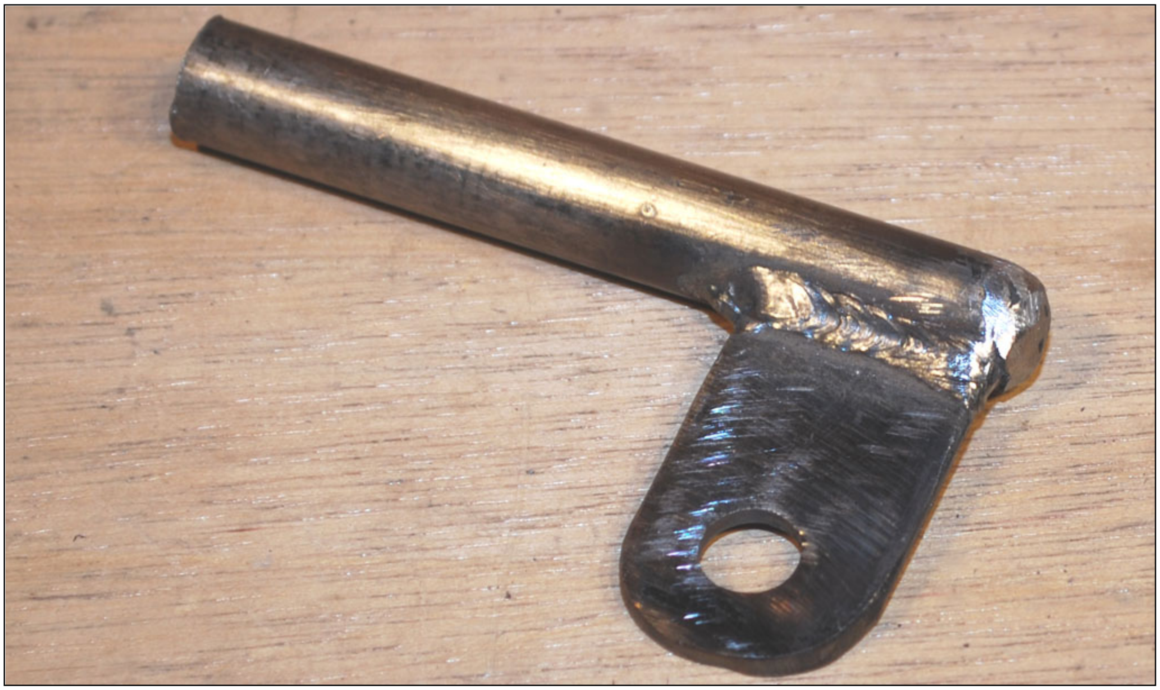

Figure 161 – Control arm and rod welded

Even the smallest tube gets a cap as shown in Figure 161, although this time the open end was just filled with welding metal. The 1.5 inch tab was welded at the end on the center of the tube to complete the part.

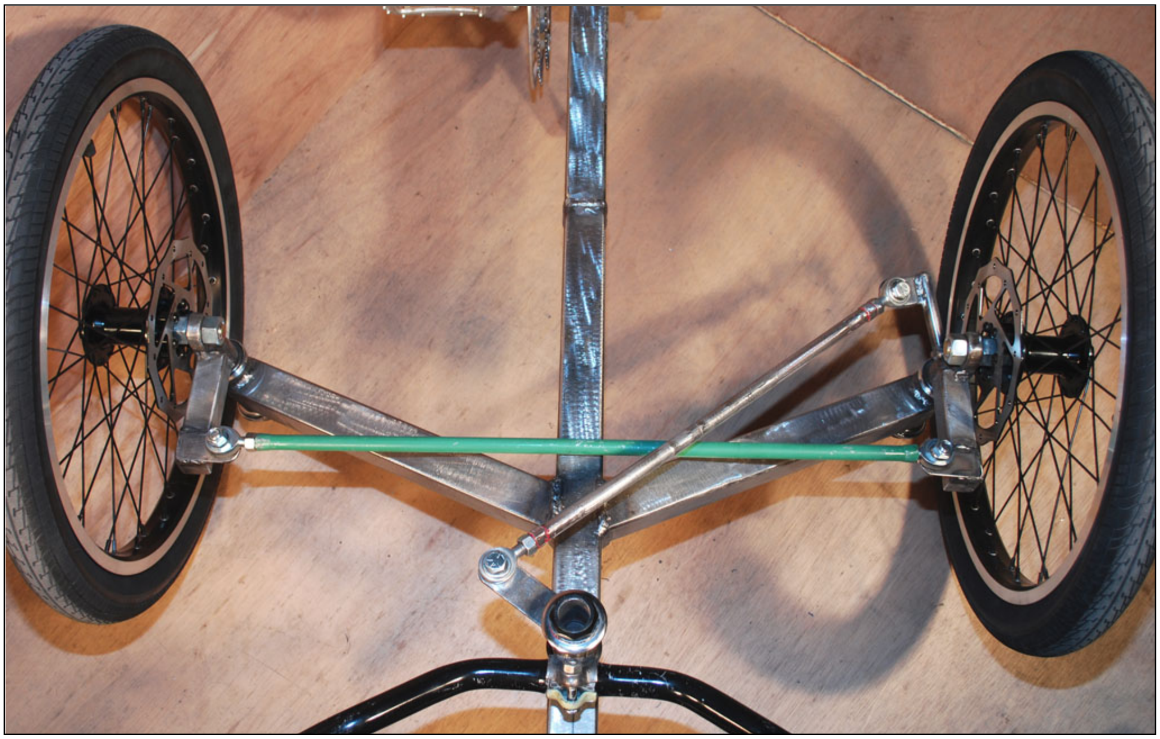

Figure 162 – Installing the rest of the steering parts

The underside of the Warrior is shown in Figure 162 after matching up all the angles as shown in Diagram 8. Remember that the new control arm is for the left wheel, which is important to allow room for the chain on the right side of the frame to sneak under the seat alongside all of the steering hardware. The control rod and ball joints are put together using the same method of setting things straight to get the hole to hole distances. Set the front wheels straight ahead, place your handlebars in the forward position, and that is your distance. You can always fine tune the threaded ball joints later if necessary.

The left wheel control arm is welded at 90 degrees to the steering boom tube, but also makes a downward angle to allow the rods to cross each other without interference. Start with a tack weld and then just tap the part downward until you can turn the wheels back and forth about 40 degrees with no rod interference. It takes a bit of tweaking to get all of these parts to live happily together, but it can certainly be done. You may also need spacers or washers on these ball joints, although this time I did not.

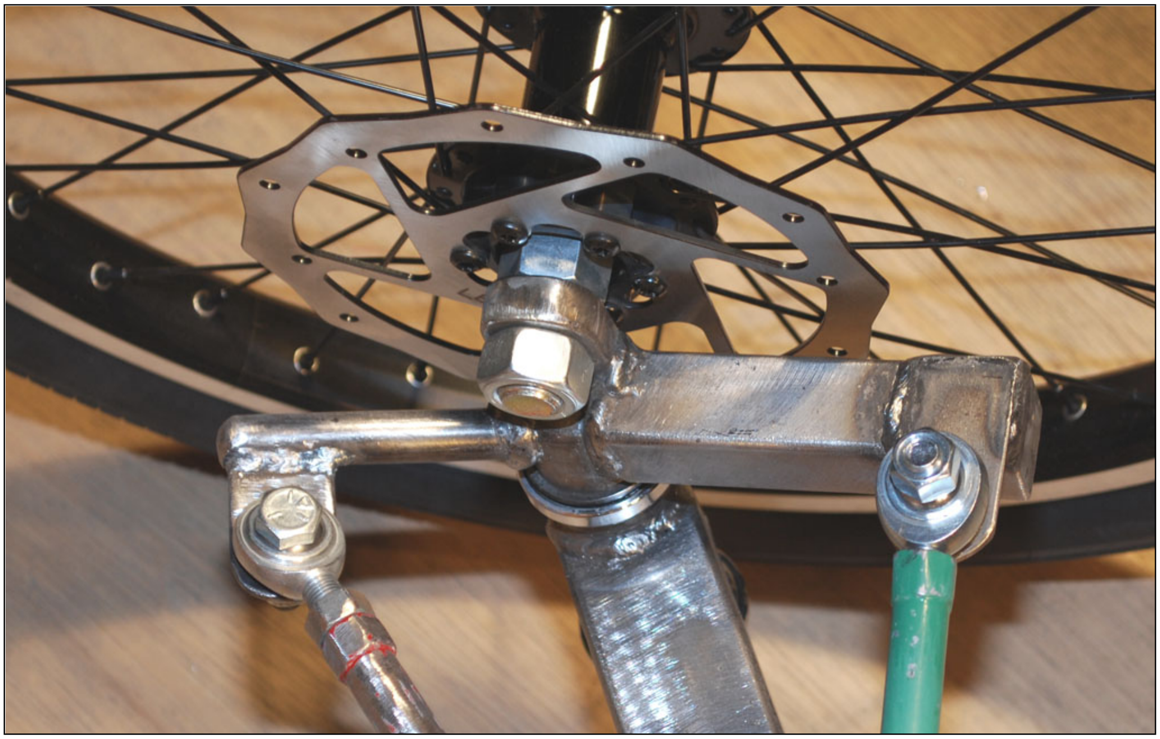

Figure 163 – Left steering control arm detail

Figure 163 shows the left control arm as well as the obvious downward angle needed to allow the control rods to overlap without rubbing together.

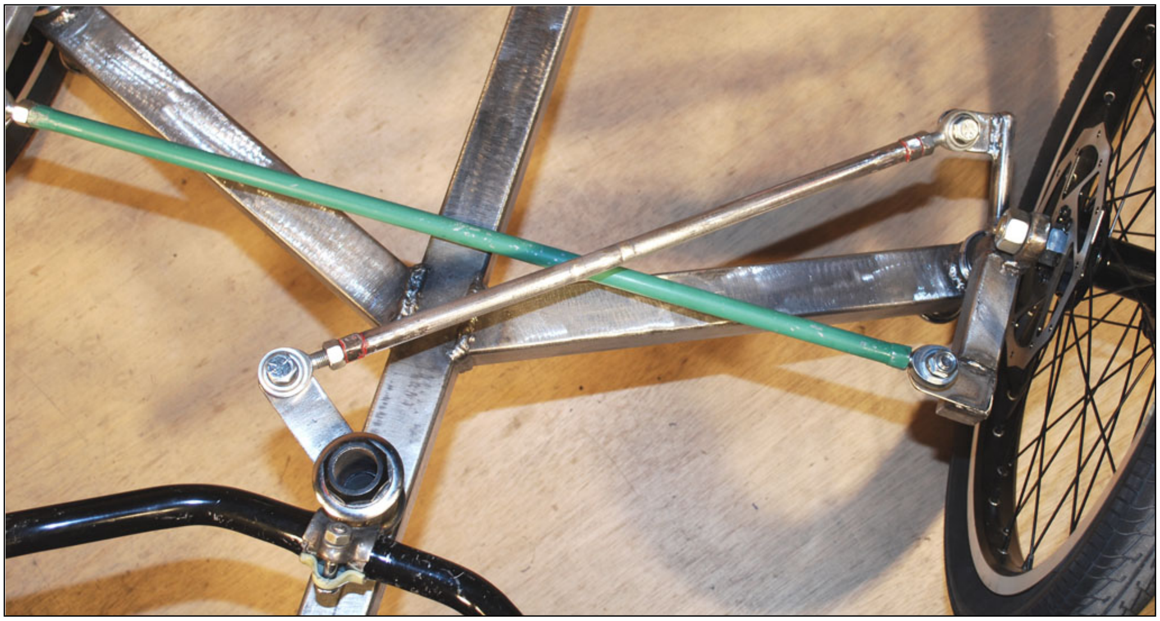

Figure 164 – Steering system set straight ahead

As shown in Figure 164, when your handlebars are at 90 degrees to the frame, the front wheels should be point in the straight ahead position.

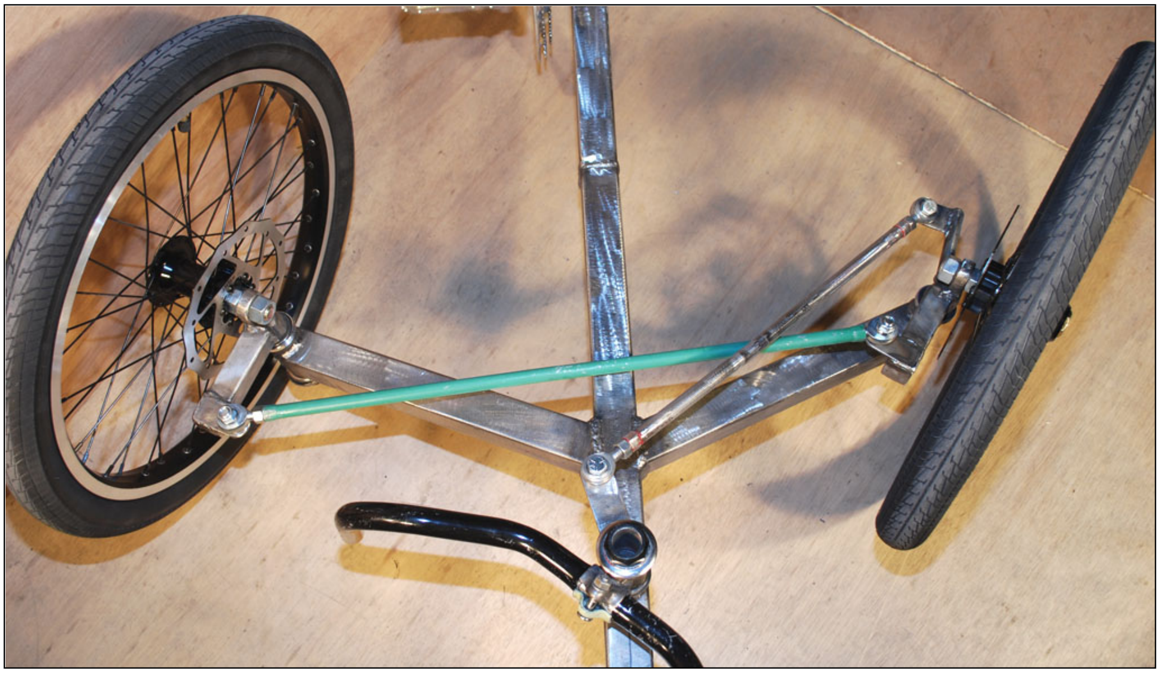

Figure 165 – Checking control rod overlap

The most you will ever need to turn a wheel is so that it is 90 degrees to the steering boom as demonstrated by the wheel shown in the left of Figure 165. My control rods come within 1/8 of an inch of each other and the frame, but there is no mechanical interference in either direction.

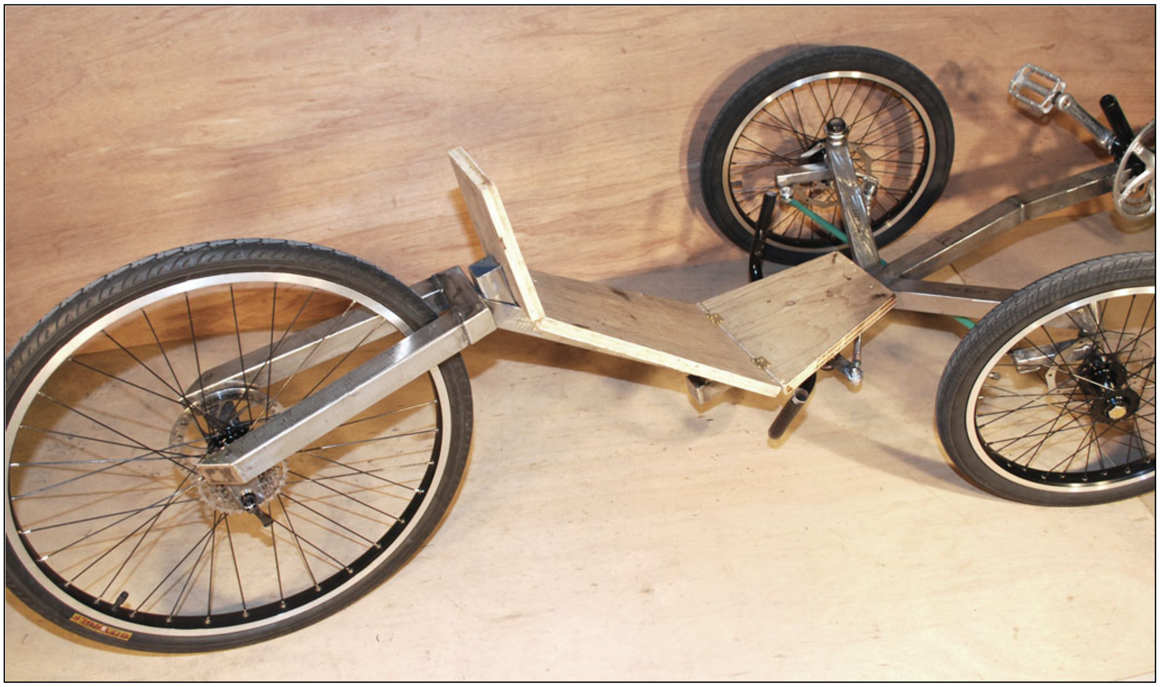

Figure 166 – You now have a rolling frame!

If you want to take a test drive to test your steering, you will need either a hill or a helper, but the trike should steer nicely without an obvious wheel dragging while you make corners. Obviously there will be a limit to how sharp you can turn before either the handlebars strike the seat or the wheels go beyond their control rods, but it will certainly be more than enough. Figure 166 shows the Warrior now that the last difficult step has been completed. It is smooth sailing from here on!

Install Chain Management System

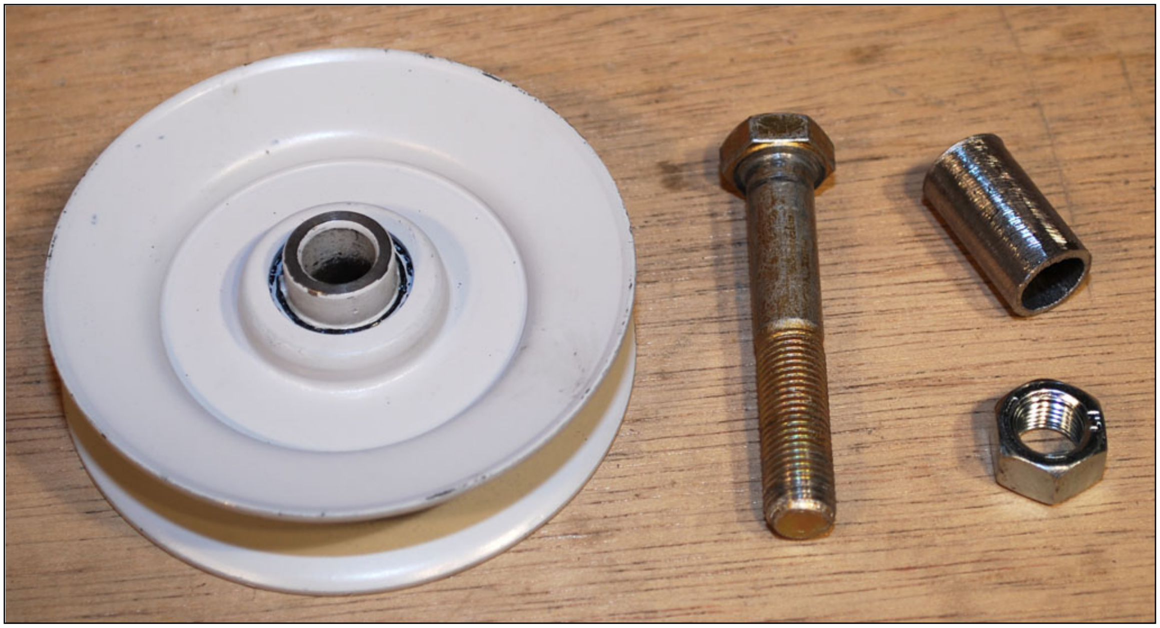

Figure 167 – A pulley to guide the drive chain

The super low racing position forced the chain to route under the seat, and it will need to have two chain guide pulleys installed in order to make the journey from cranks to rear wheel. The best option for a guide pulley is a 2.75” to 3.5” diameter belt pulley made for a ½ inch V-belt. This pulley will come with a decent bearing in the center and will allow the chain to sit nicely in the groove, making no sound whatsoever as you pedal.

Nylon or steel will work fine, but you should definitely avoid using any guide pulley with a diameter less than 2.75 inches, and don’t even try to use a rubber skate blade or skateboard wheel for this. You will need two identical idler pulleys, and they can be purchased at most hardware stores or any shop that services lawn and garden equipment.

Front Idler Pulley

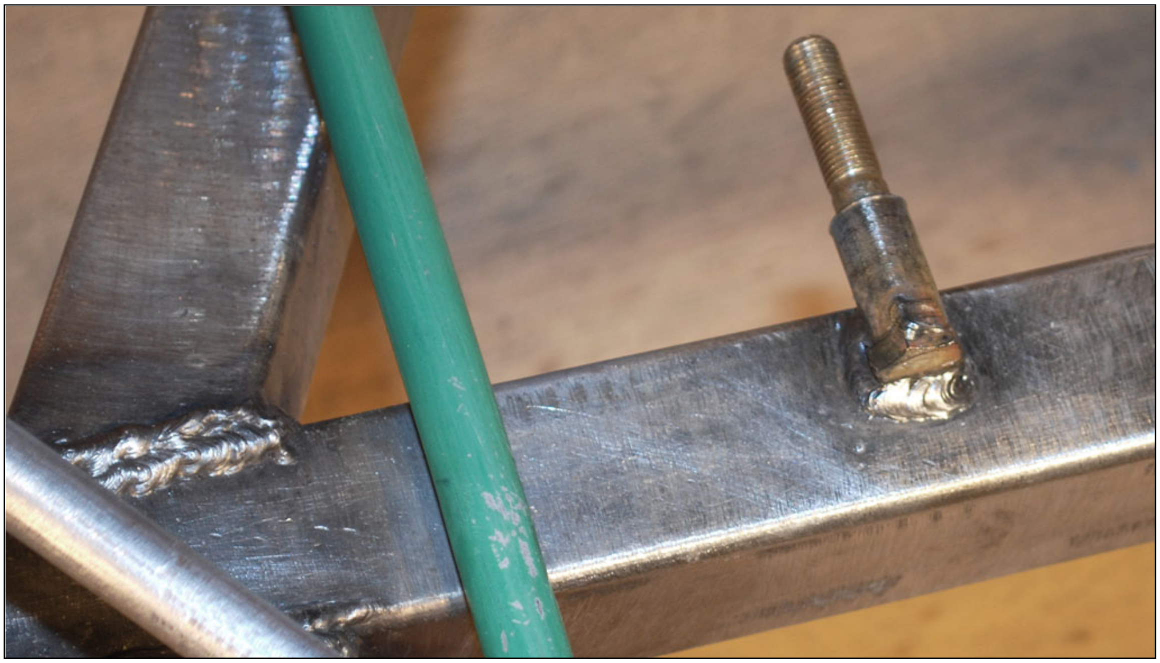

Figure 168 – Adding the front idler pulley

The front idler pulley is positioned just ahead of the control rod that joins the two front wheels. It needs to be placed about half an inch off the boom so that it is inline with the large front chain ring as this is the one you will do most of your riding in. The spacer shown in Figure 168 and 167 is just a bit of scrap tubing left over from making the control rods.

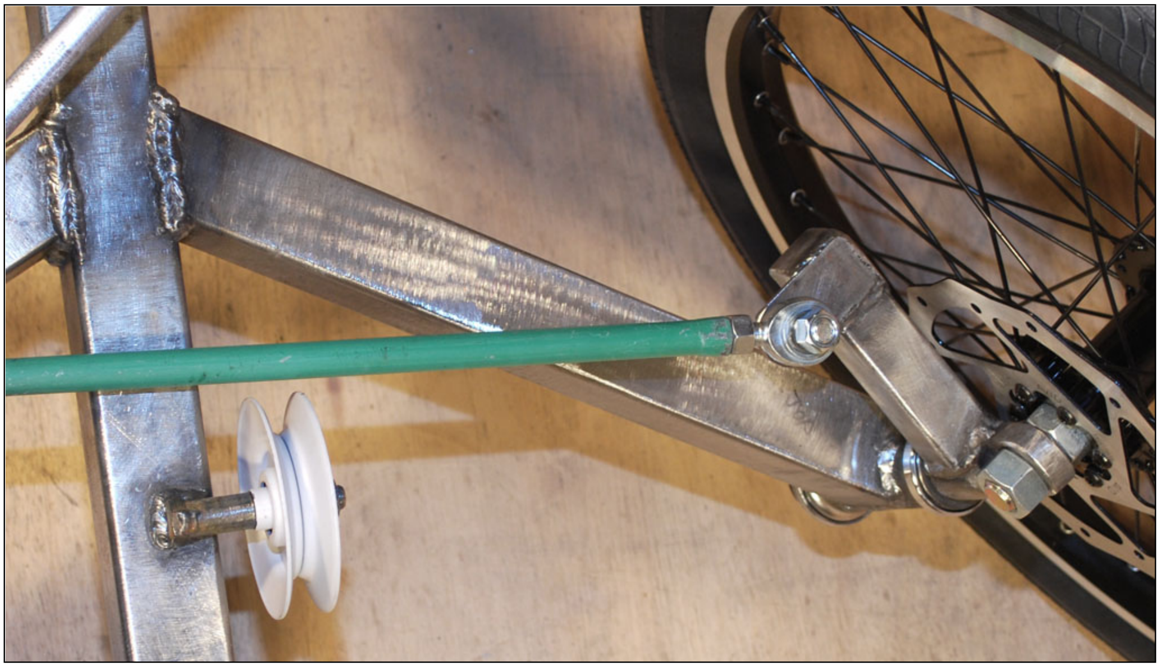

Figure 169 – The pulley must not interfere with the control rod

To find the optimal position for the front pulley, turn the steering to the maximum right and left so you can see how far the control rod moves forward. The pulley should be installed just ahead of this point, which is about an inch as shown in Figure 169.

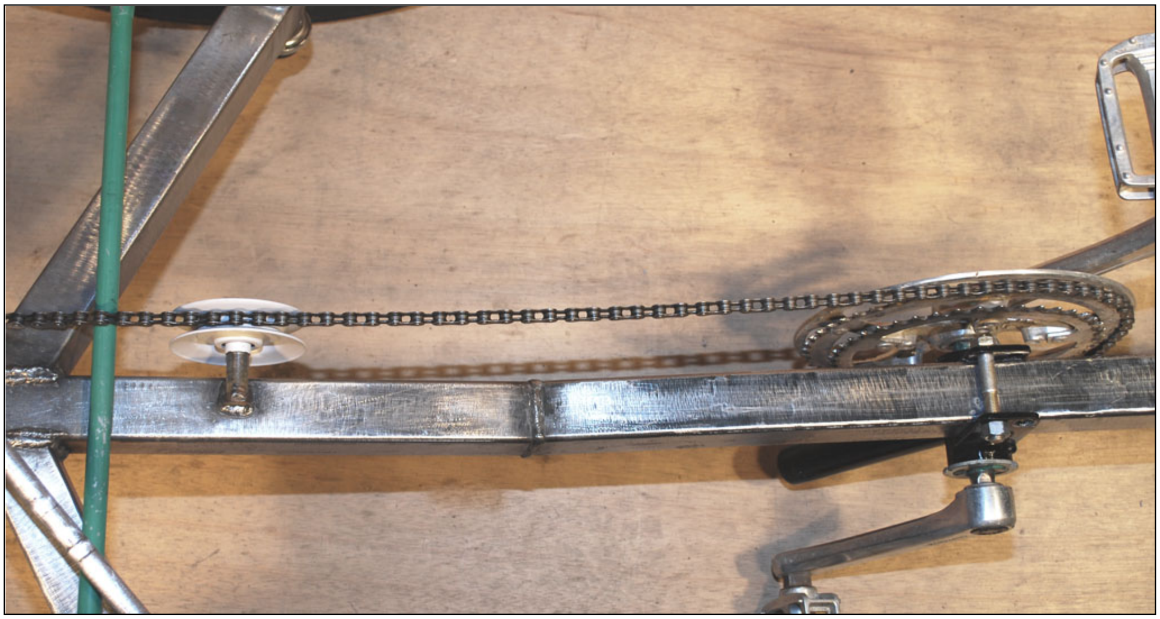

Figure 170 – The idler lines up with the large chain ring

Since most riding will be done in high gear (the largest front chain ring), the idler should line up with that ring. If you have a 3 ring front crankset, have the idler more in the center, as it will keep chain noise to a minimum that way.

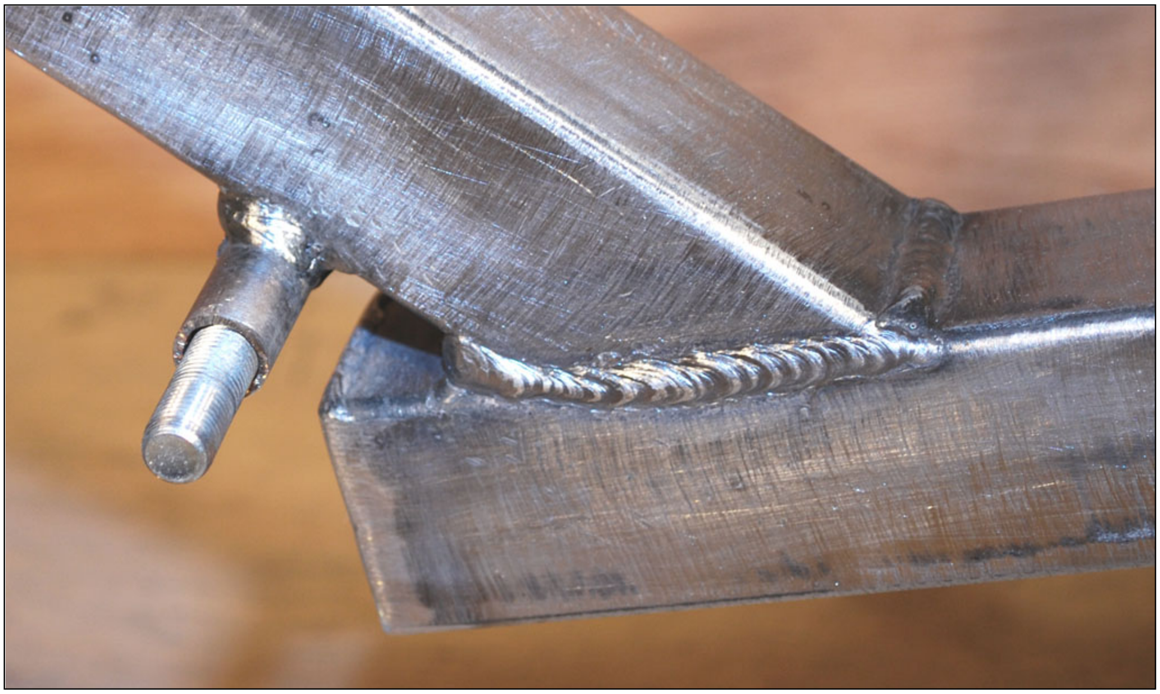

Figure 171 – Adding the rear idler pulley bolt

The rear chain guide pulley is the same as the front one, and will have a bolt and spacer welded to the seat tube just above the joint as shown in Figure 171. When adding the idler, check to ensure that it does not rub on your seat when the boards are installed on the frame.

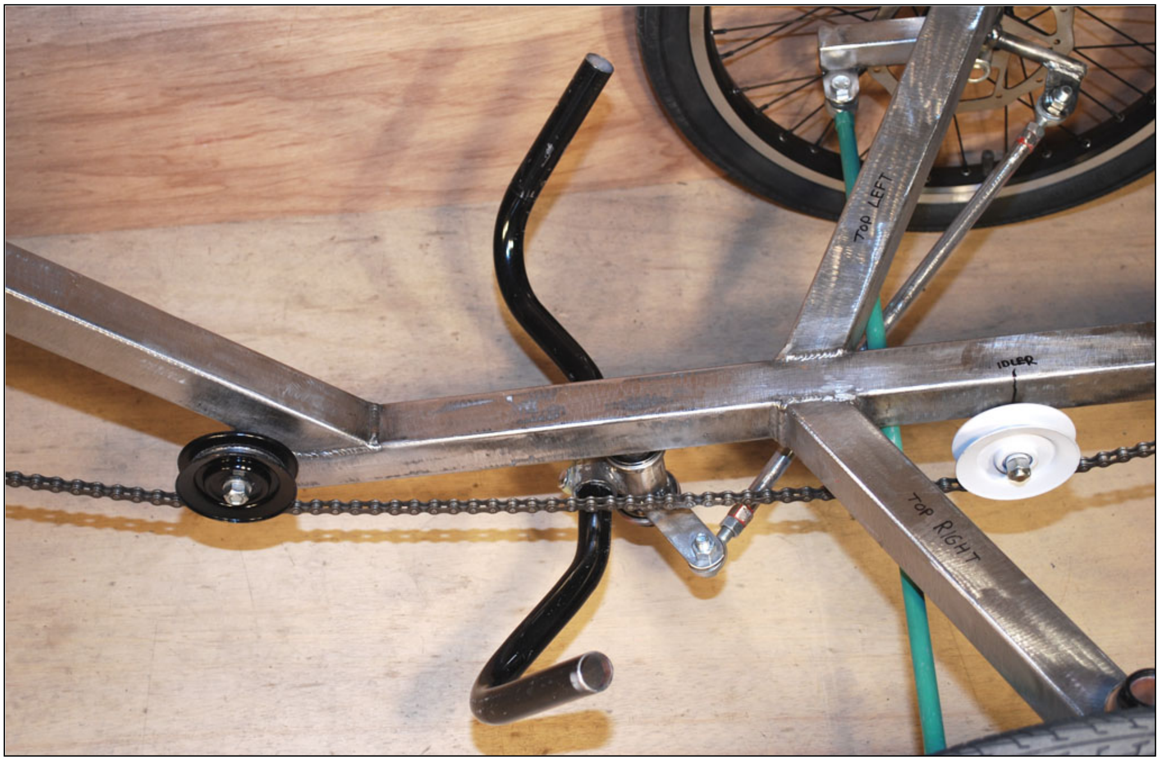

Figure 172 – The chain treads carefully under the seat

There is not a huge amount of room under that low frame for the chain, and it must share the space with all of the steering hardware. As shown in Figure 172, the chain travels under the front pulley, over the control arms and rods, under the rear pulley, then off to the rear cluster. This is the drive side of the chain that does all of the work, so it enters the top chain ring at the crankset and leaves from the top cluster on your rear wheel. The non drive side of the chain (return chain) is much easier to route as it is never under any tension and is always slack.

If you find the drive chain rubbing on any steering parts, you may need to "tweak" the position of guide pulleys. Start with the rear pulley, but remember that seat board.

Return Chain Tube

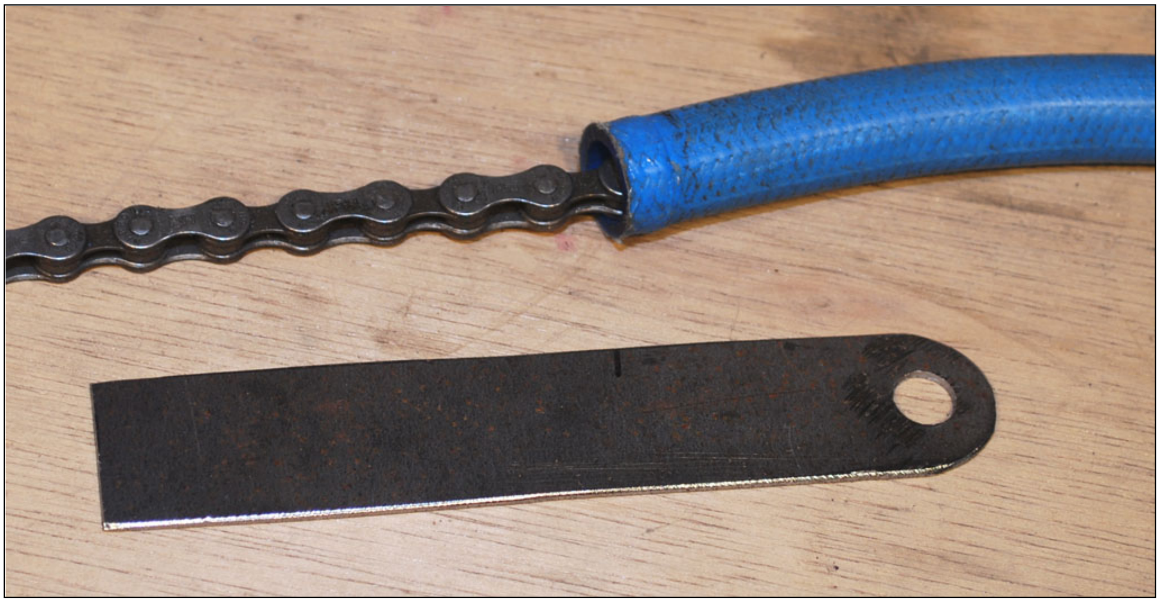

Figure 173 – Making a return chain tube

The return chain must also live under the seat, but due to it having no tension at all, a simple rubber guide hose can route it wherever you want without robbing any power from your pedaling input. The garden hose shown in Figure 173 will be held around the sheet metal strip by bolting it to the front idler pulley as shown later in Figure 177. Any hose will work, as long as the chain slides through it easily.

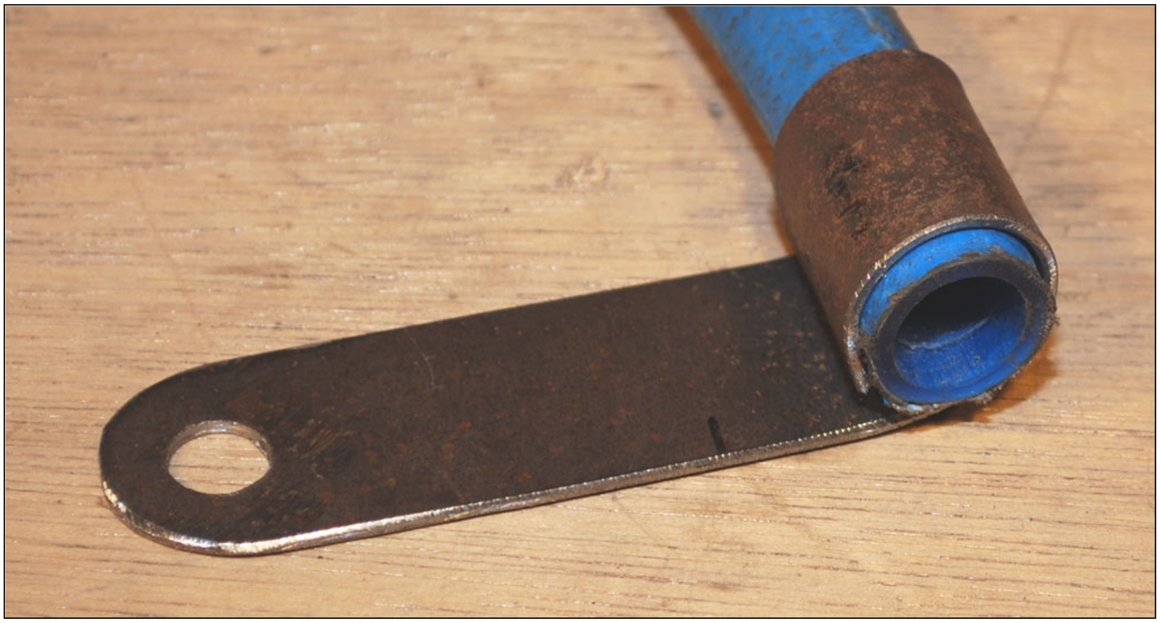

Figure 174 – Making the holder for the chain hose

The small strip shown in Figure 174 was cut from some thin sheet metal, and then bent around the hose to make a holder to bolt onto the front idler pulley. The dimensions are not critical, but for reference, this part measures about 3 inches from the bottom of the hose to the top of the bolt hole.

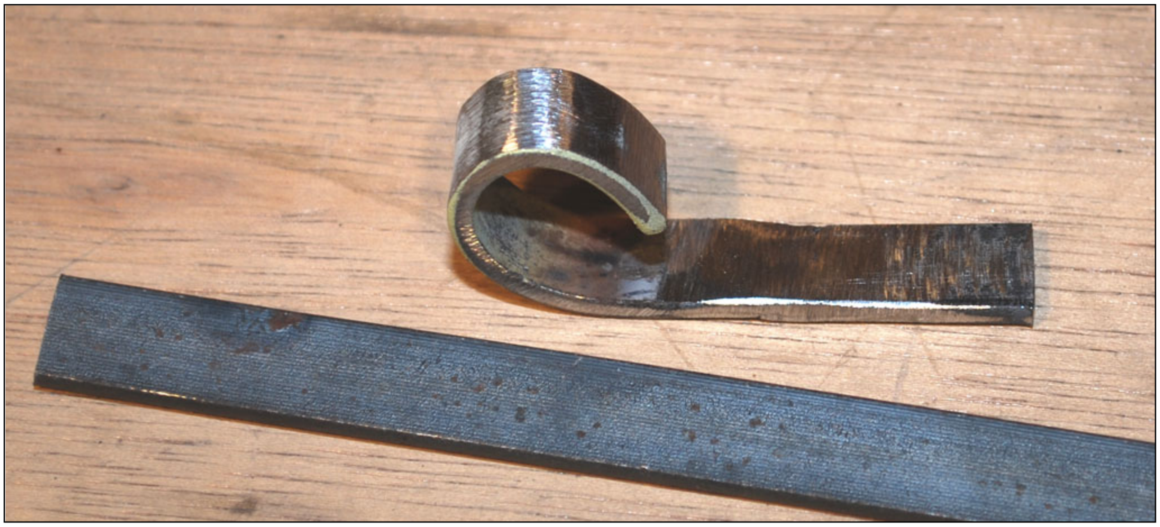

Figure 175 – The rear hose holder

The same type of system is used to hold the rear of the chain hose, which will exit somewhere near the rear idler pulley. I bend another bit of flat bar into a holder, making it a little shorter for the rear part (about 2.5 inches total after bending).

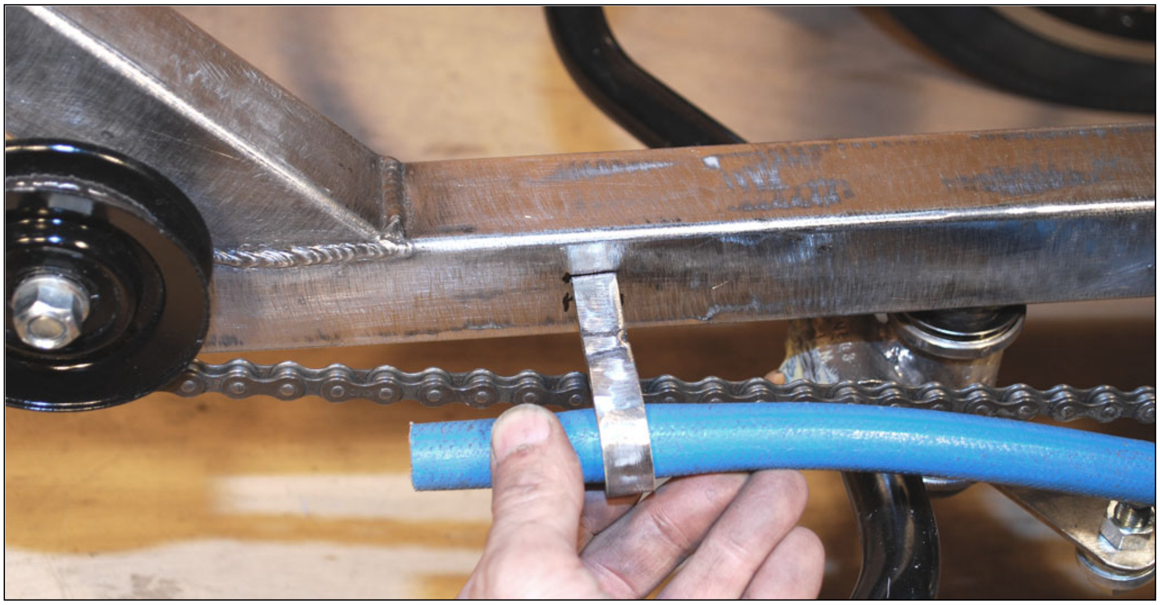

Figure 176 – Rear chain hose guide installed

The rear chain hose guide is installed close to the rear idler pulley. In Figure 176, I have it under the seat, but it would probably be better if it was about an inch away from the edge of the rear idler pulley. I did this because I only had a short piece of hose to use!

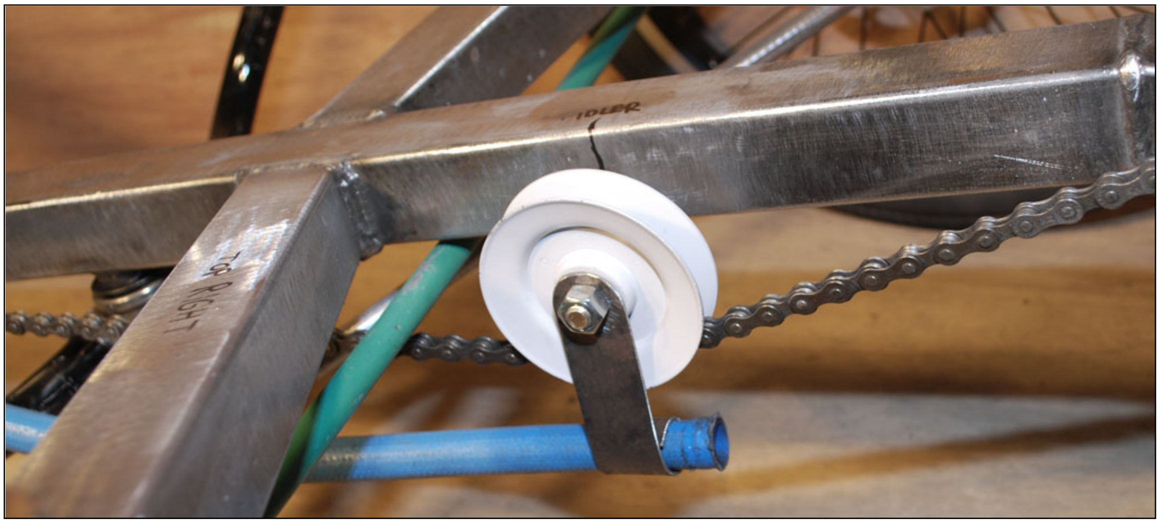

Figure 177 – Front chain hose guide installed

The front of the chain hose will rest just under the front idler pulley as shown in Figure 177 because it is held on by the idler pulley bolt.

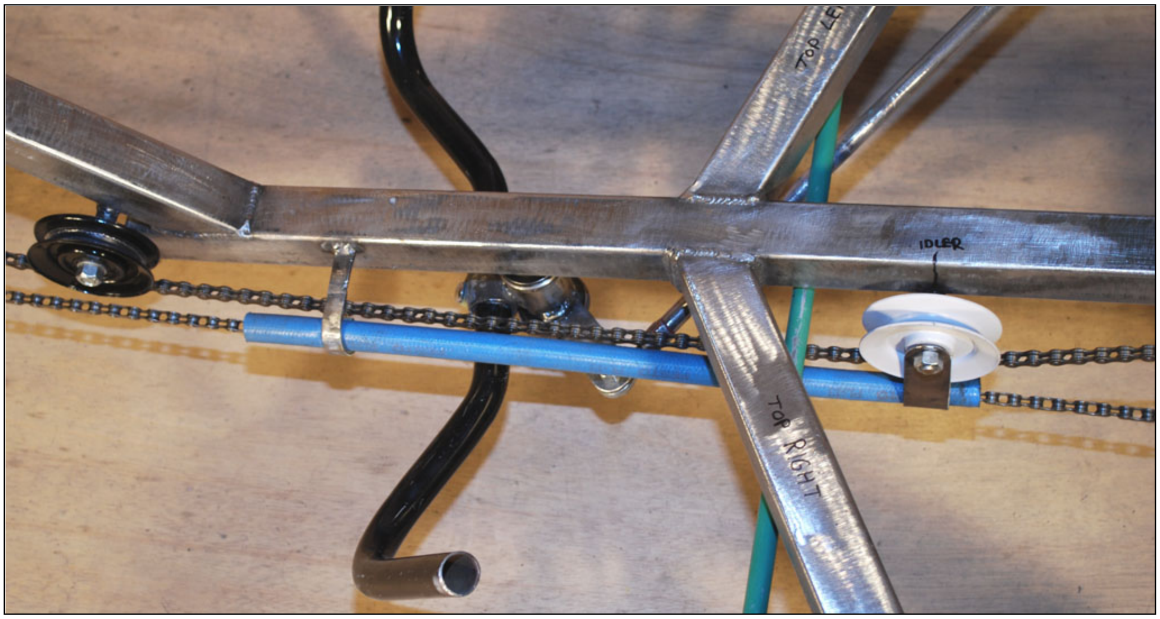

Figure 178 – Adjusting the chain guide hose

The chain guide hose should be “massaged” into the best position so that it does not rub on the moving steering parts or the drive chain. A little rubbing is not a big deal since there is no tension in the chain, but it wasn’t difficult to set it up so that there was no interference at all. Figure 178 shows the chain guide tube parked slightly to the right of the drive chain, but following the same route through all of the steering hardware.

Chain Length

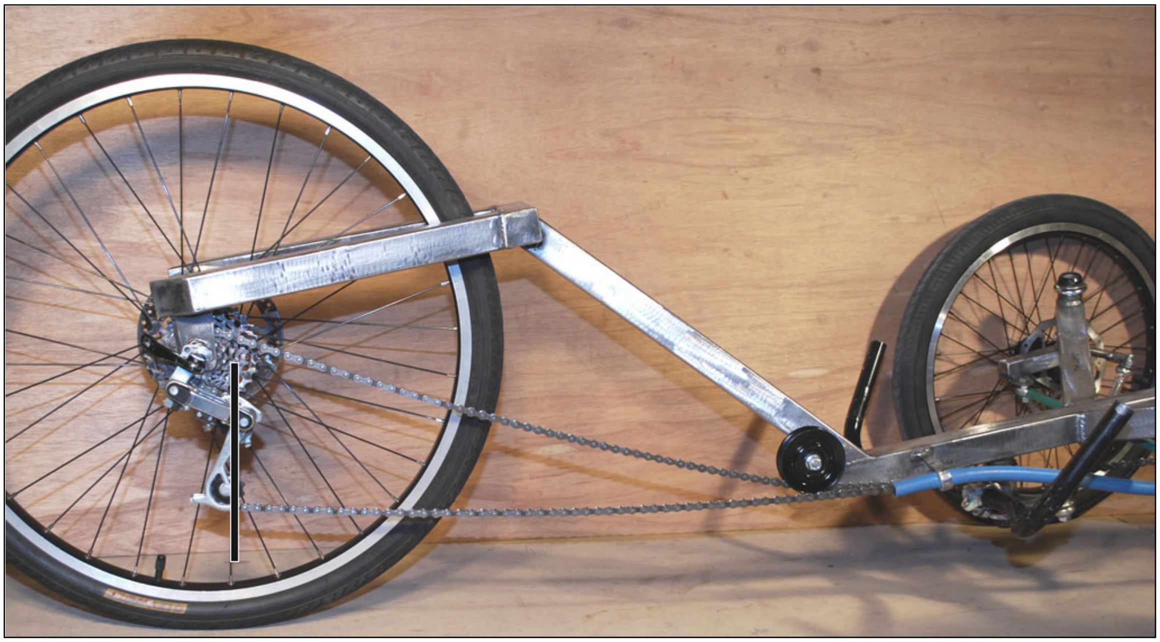

Figure 179 – Setting up the best chain length

It will take a bit of testing to get your chain to the optimal length, and having an inexpensive chain link tool will make the procedure very easy. As a guide, set your chain on the large front chain ring and the midsized rear wheel chain ring and make a chain that when installed, sets your rear derailleur inline as shown in Figure 179. The rear derailleur on the Warrior is installed on the right rear dropout in the same position it would be sitting on a typical bicycle. I welded a small bit of the tab on my derailleur to the dropout to keep it there, but that is optional, and you could also drill a hole and add a small bolt where the small hole on the derailleur plate is to hold it at the desired angle.

Install Disc Brakes

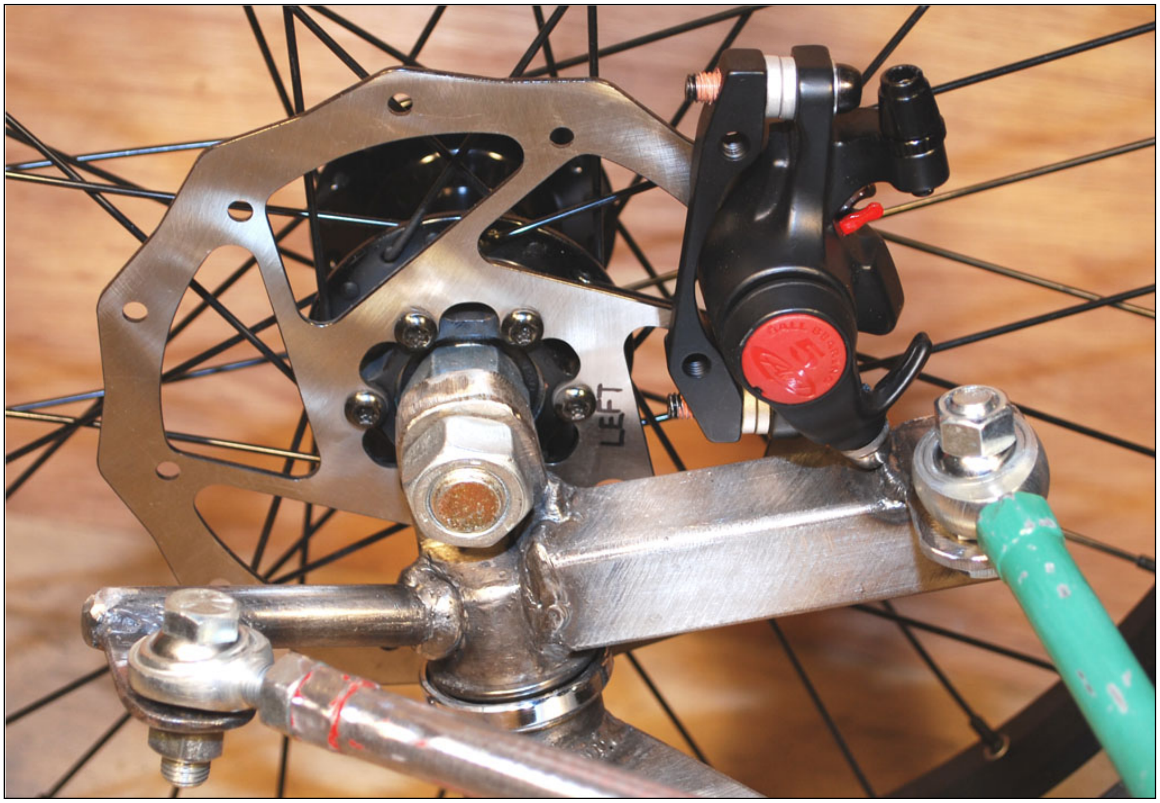

Figure 180 – Determining front disc brake positions

Installation of the disc brakes is not a difficult job, but there is no “one size fits all” solution due to the many sizes and shapes of brake hardware available. Most brakes do have one thing in common - they have vertical mounting holes and the ability to be tightened up to lock onto the disc. By locking the brake on the disc as shown in Figure 180, you can then build around the brake and square tube, using some paper and scissors to hack out a decent mounting plate template. If your brake has no locking abilities, just use a tie wrap to lock the lever in the full braking position to clamp it onto your disc rotor.

Also, keep in mind the position of the pads as compared to the rotor. The pads should fit onto the face of the rotor as fully as possible, and the non-round rotors, like the one shown in Figure 180, take a little more care to avoid having the raised areas bump into the brake hardware.

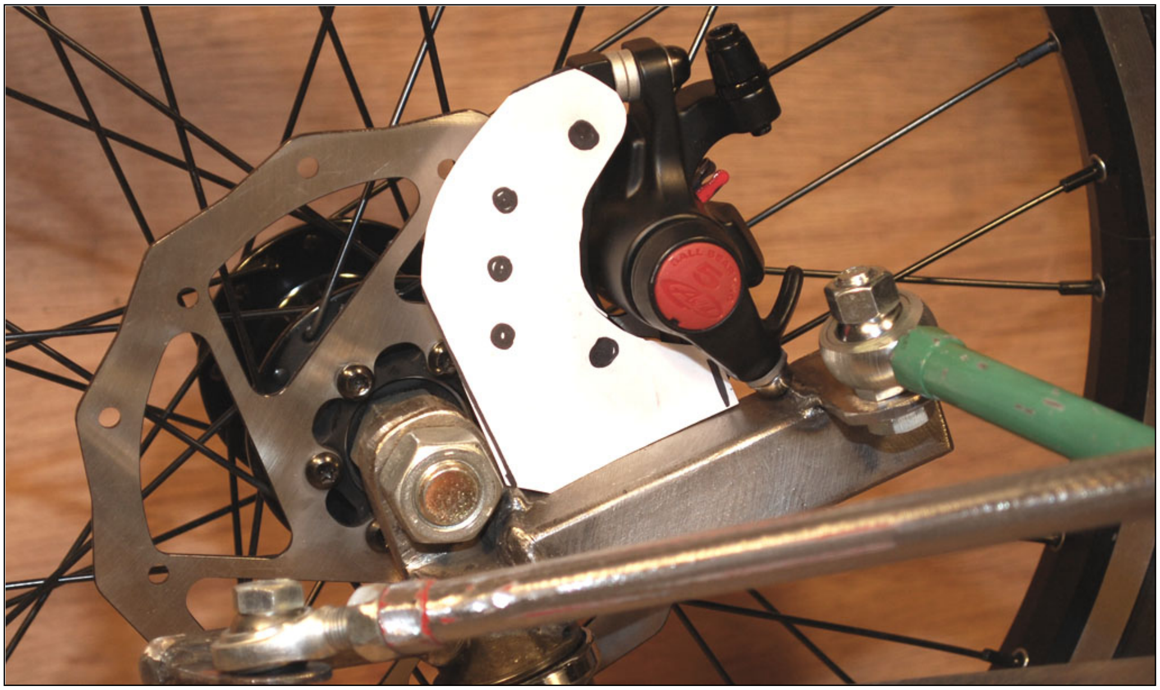

Figure 181 – Making a paper template

Set up the brake caliper so that it is tightly clamped to the rotor, ensuring that the pads are in the perfect place and the levers are accessible to cables. One brake will have the cable entry on the top, and the other will be on the bottom due to the mirror effect, but this is OK, and expected. There is no right and left trike brake available for trikes that I know of. After a bit of trial and error, the paper template for the right side brake was made (Figure 181).

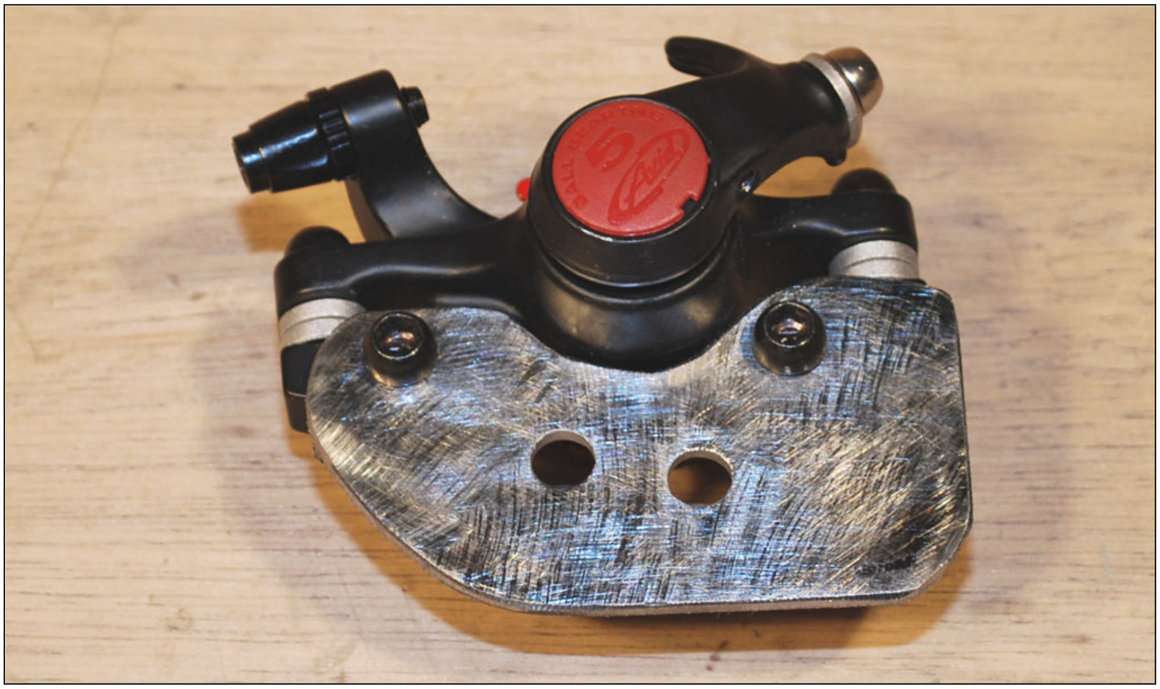

Figure 182 – Cutting out the brake mounting plate

The brake mounting plate shown in Figure 182 was carved from the paper template shown in Figure 181, and then drilled to fit the brake hardware. The plate is 1/16 flatbar rough cut with a zip disc and then ground into shape. A jigsaw with a metal cutting blade would also work for this.

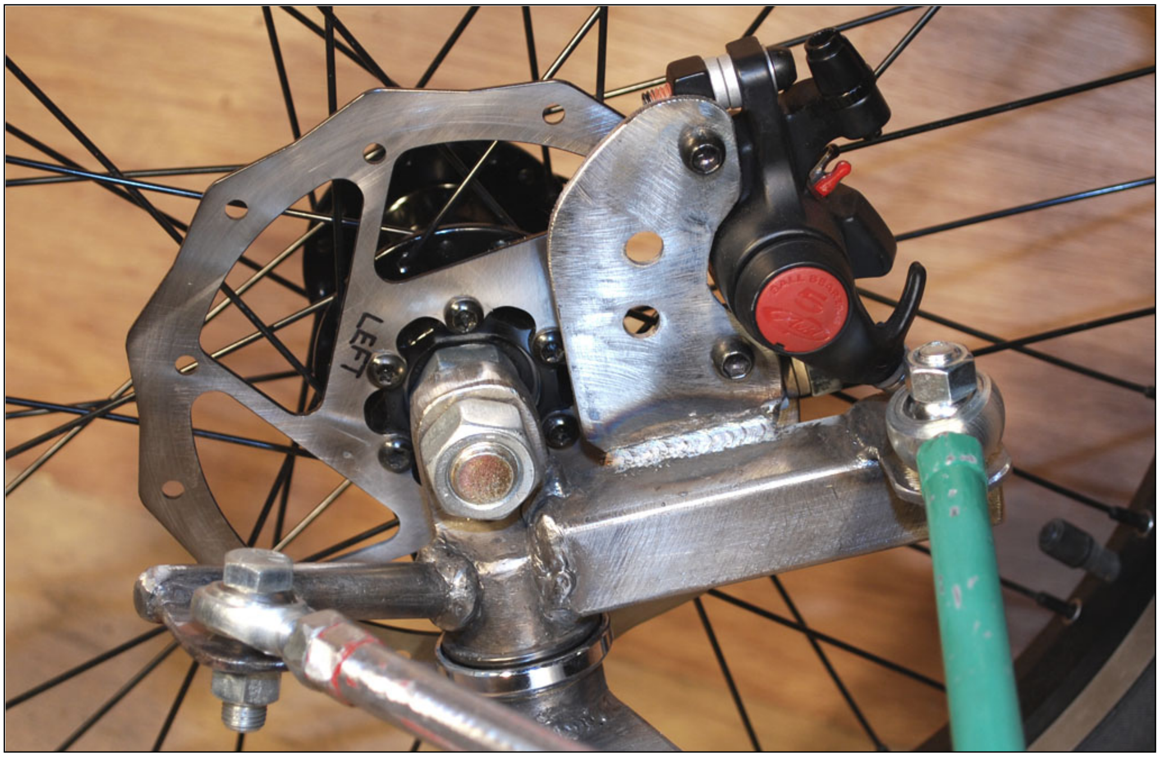

Figure 183 – Right side brake installed

To align the brake mounting plate into the perfect position, clamp the caliper to the rotor, cover it with cloth or tape, and then weld the plate with everything in place. You will also want to protect the rims, hub, and caliper when welding so close to them. The other side of the plate can be welded later, when you clean up the frame for painting. Once the brake mounting plate is installed, back off the brake caliper tension and give the wheel a spin – there should only be a small amount of rubbing, which is normal for a new brake. The wheel should spin freely without much friction. If the wheel seems to jam up, even with the caliper back off a lot, tap the plate in whatever direction it needs to go, as it may have shifted after the weld cooled.

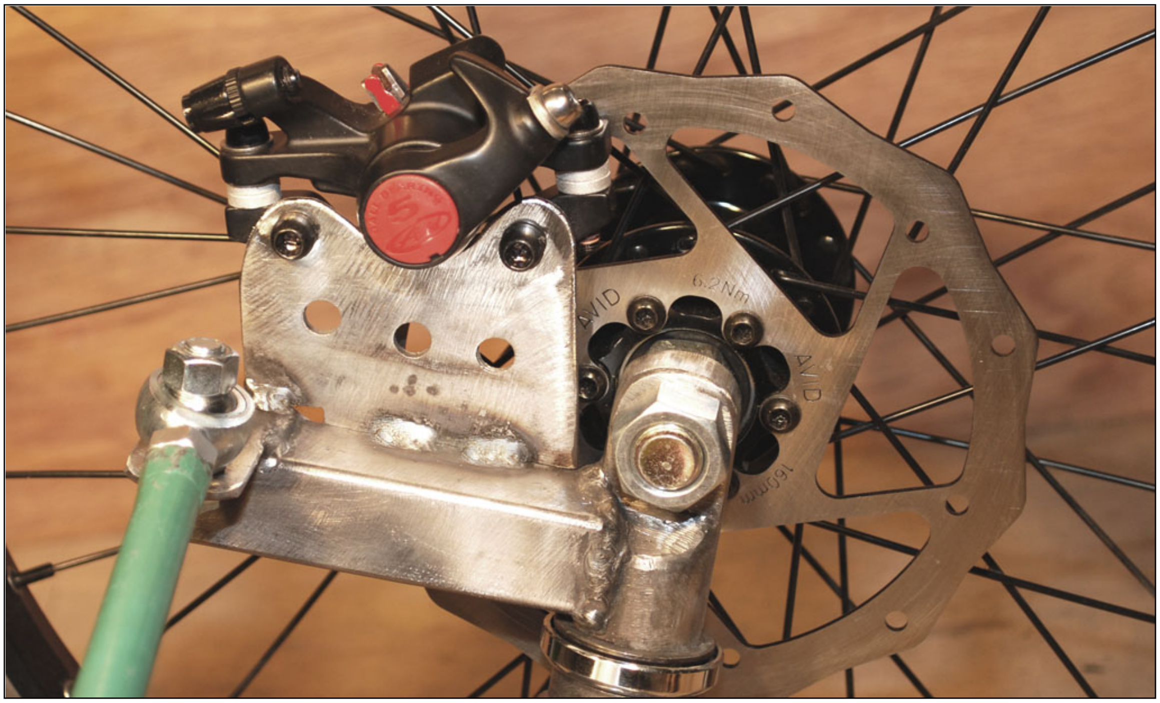

Figure 184 – Left side brake installed

The left side brake hardware shown in Figure 184 looks quite a bit different than the plate shown in Figure 183 mainly because the brake is installed the other way around. On the right side, the cable enters from the underside of the trike, and on the left side it enters from the rear of the trike. The paper template and weld in place method was used to align both brakes.

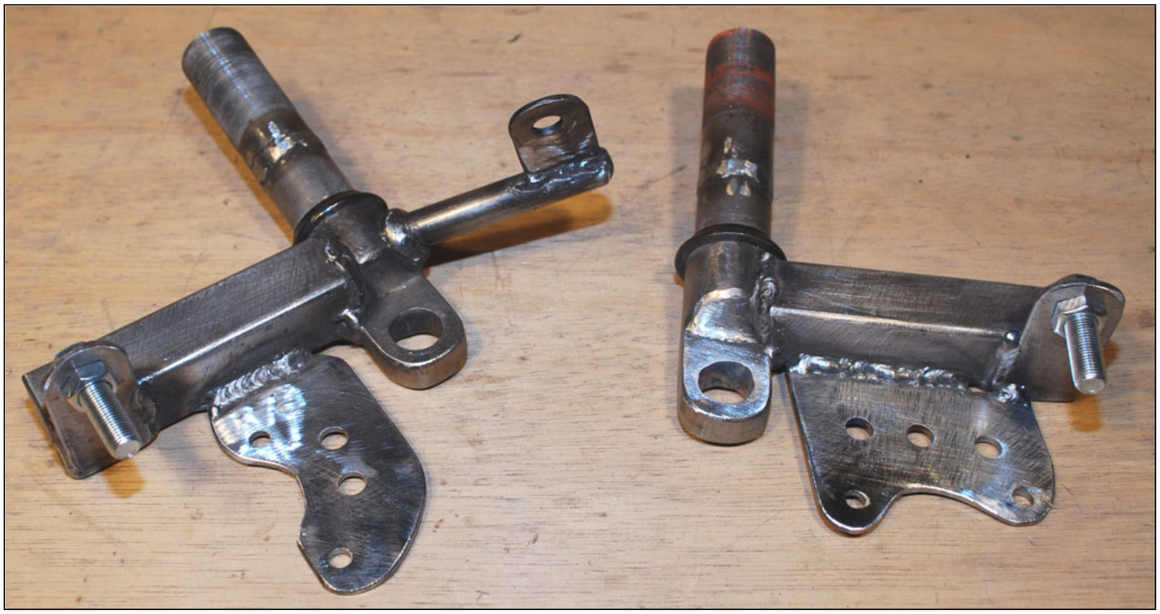

Figure 185 – The completed steering parts

The front steering hardware shown in Figure 185 looks quite complex, but since it was built one step at a time, is not really all that confusing. Imagine trying to make these things all at once from a CAD drawing without a CNC machine?? Yikes.

Also shown in Figure 185 is the ground down nuts acting as spacers for the ball joints to stop the bodies form rubbing on the control arms during turns.

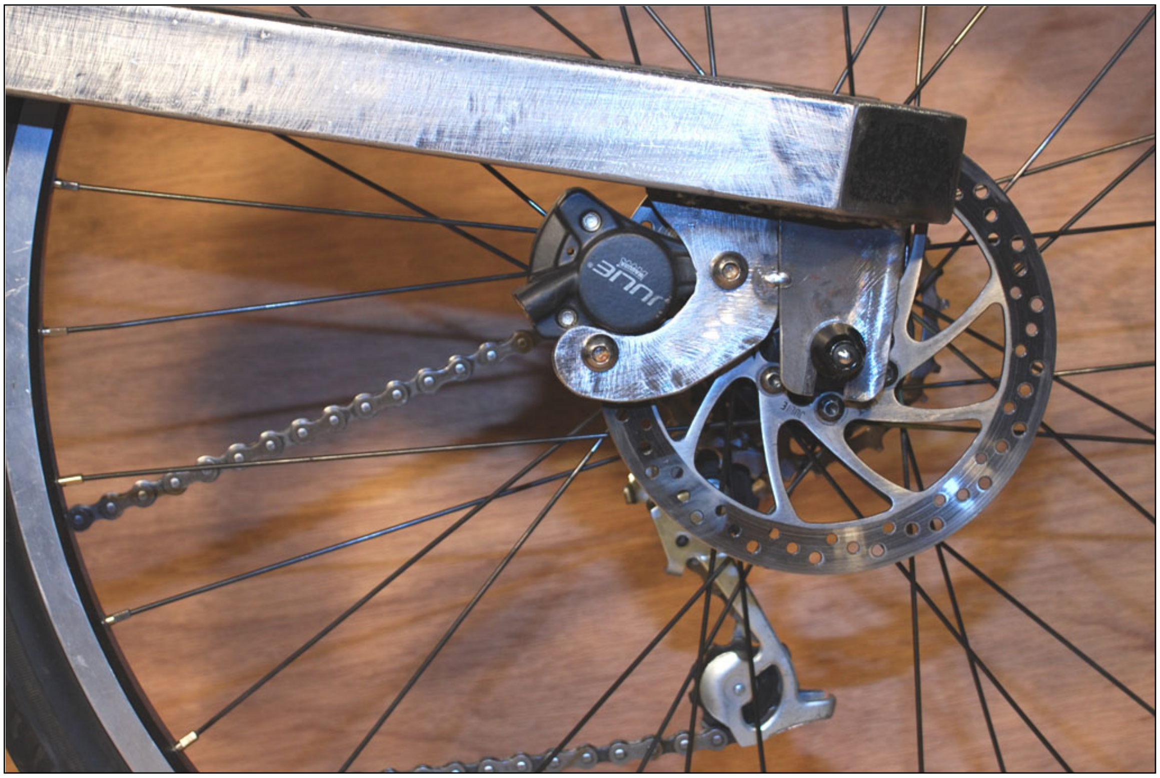

Figure 186 – Installing the rear brake

Although I added a hydraulic rear brake, the process of clamping and making a template was exactly the same, and the completed brake is shown mounted in Figure 186. A rear brake is really optional, and you have to deal with three cables into two levers, so unless you love to do fishtails and T-slides, the third brake is probably unnecessary.

Adding the Finishing Touches

Seat Mounting Tabs

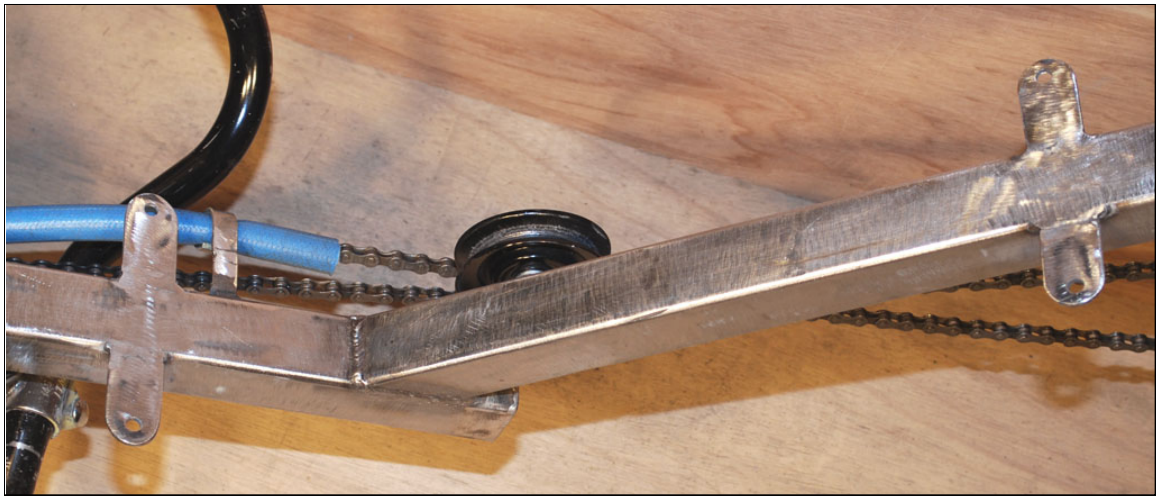

Figure 187 – Adding seat mounting tabs

If you are using a simple wood and foam seat like I am, then a set of tabs for the base and back will be needed to secure it to the frame. Figure 187 shows the four tabs, which are 3 inch long pieces of 1/8 inch thick flatbar with holes drilled near the end for woodscrews. A mesh seat will require a more radical mounting system, and some height from the frame.

Back Rest Tube

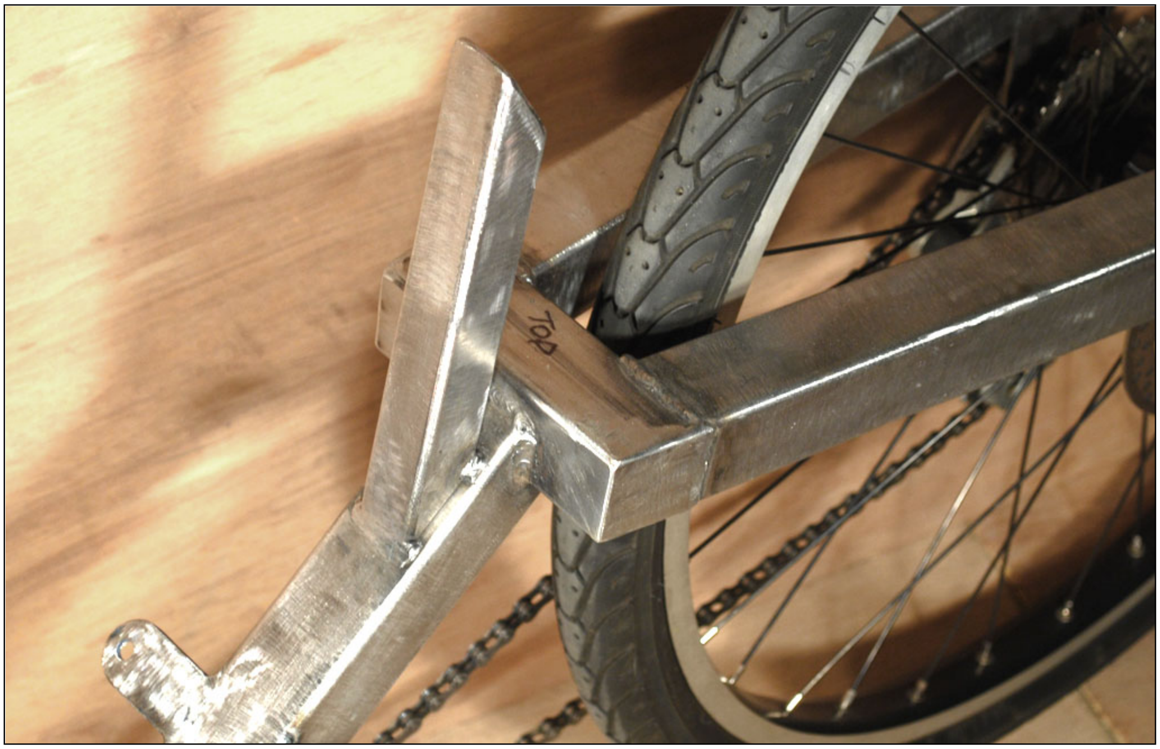

Figure 188 – Adding a back rest tube

The wood and foam seat is extremely comfortable and keeps the Warrior nice and low, but a third section called a backrest was necessary. A head rest cannot be used on a recumbent because vibration will rattle your teeth out, but a seat that comes up to the tallest part of your back becomes very comfortable. The 1 inch tube shown in Figure 188 was added to the end of the seat boom at an angle that seemed most comfortable when sitting back in the seat.

Front Boom

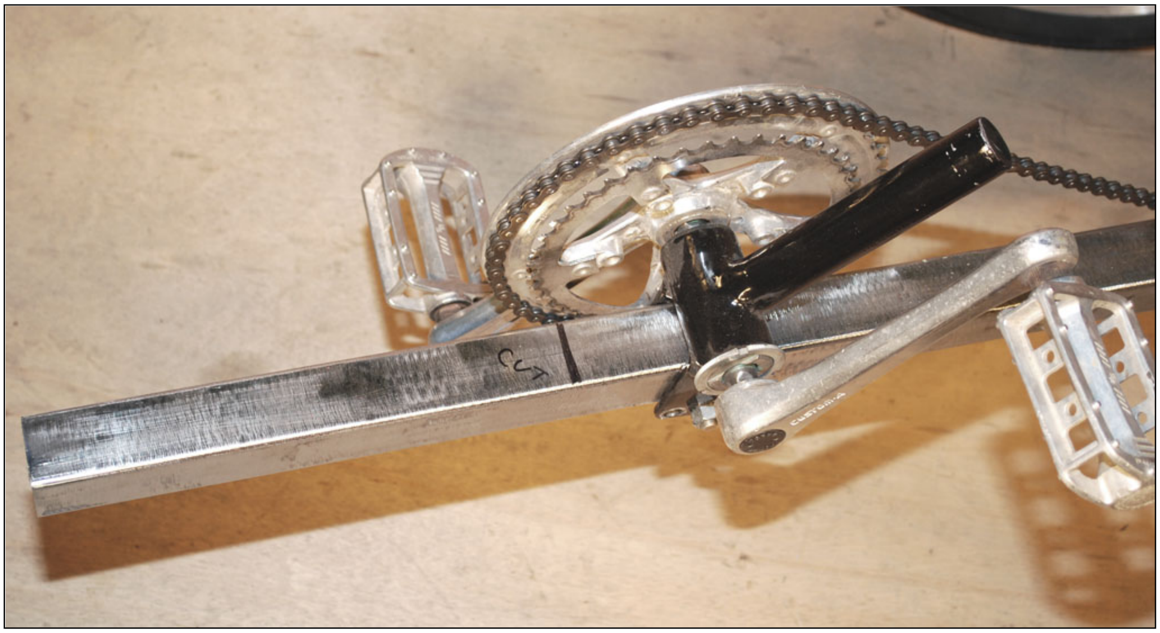

Figure 189 – Marking the boom for trimming

Unless you are a world record contender for being tall, you will most certainly need to trim some of the excess front boom length. Set the bottom bracket ahead as far as it will ever need to be, then make a line about 3 inches beyond that just to be safe (Figure 189). Also remember to do this with a fully padded seat and while you are wearing shoes.

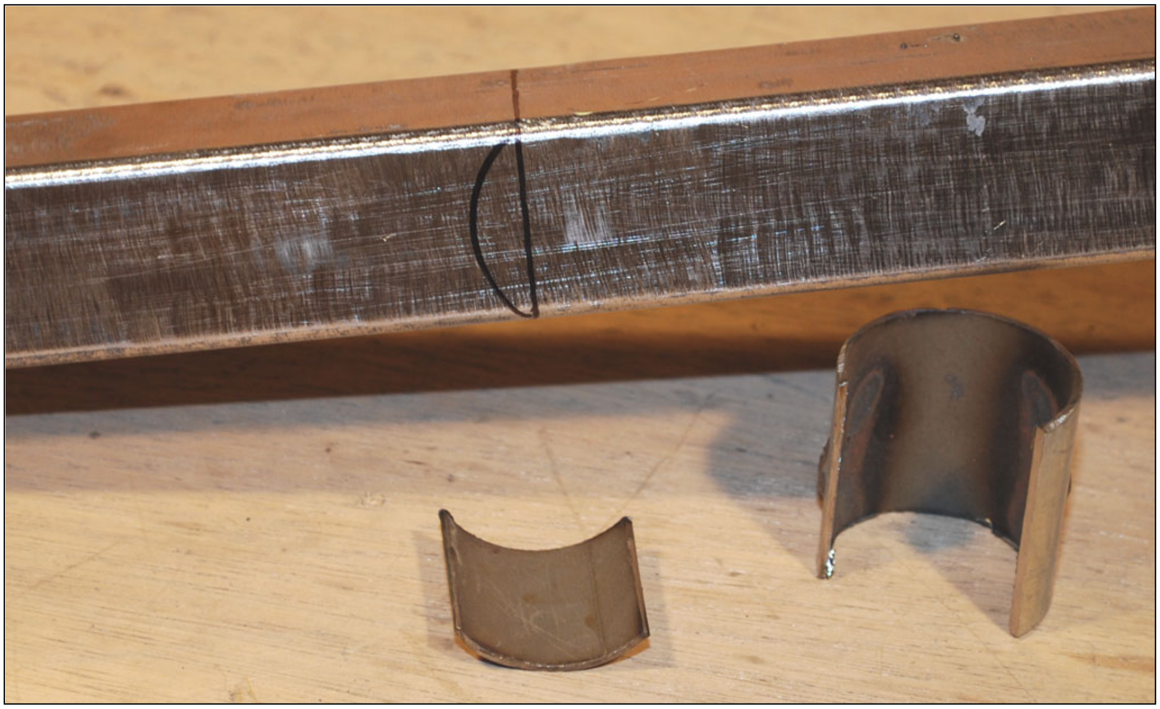

Figure 190 – Making a rounded end cap

Since the front of the boom is always noticeable, I decided to do a fancy rounded end cap by hacking out a bit of round tubing as shown in Figure 190. A square cap would look nice as well, but I like the little details.

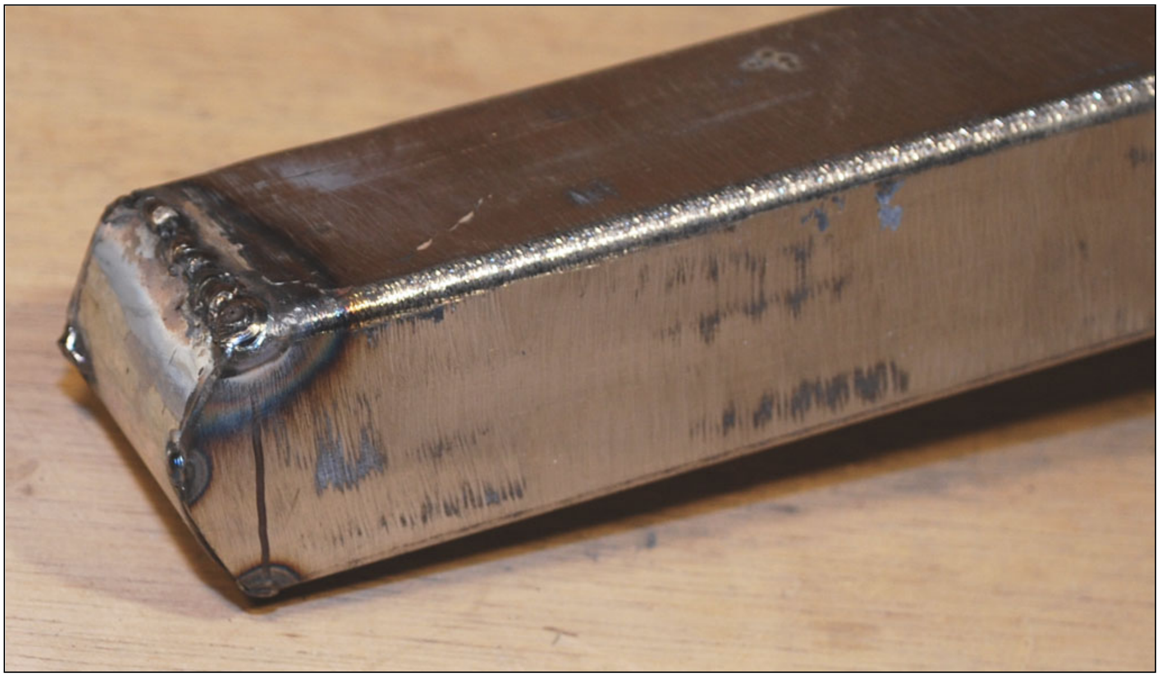

Figure 191 – Welding the rounded cap

The walls of the tube are cut to match the round of the end cap as shown in Figure 191. A few tack welds hold the cap in for final welding.

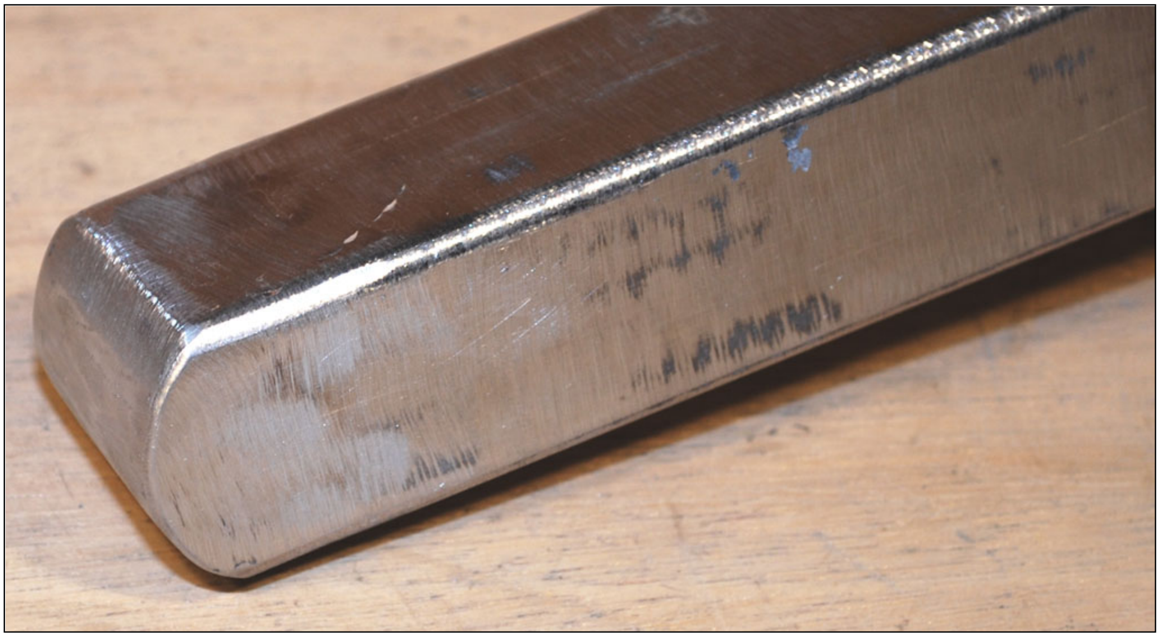

Figure 192 – The rounded end cap ground clean

Steering Caps

The rounded end cap shown in Figure 192 gives the front of the boom a little style as well as adding a shield from the outside elements.

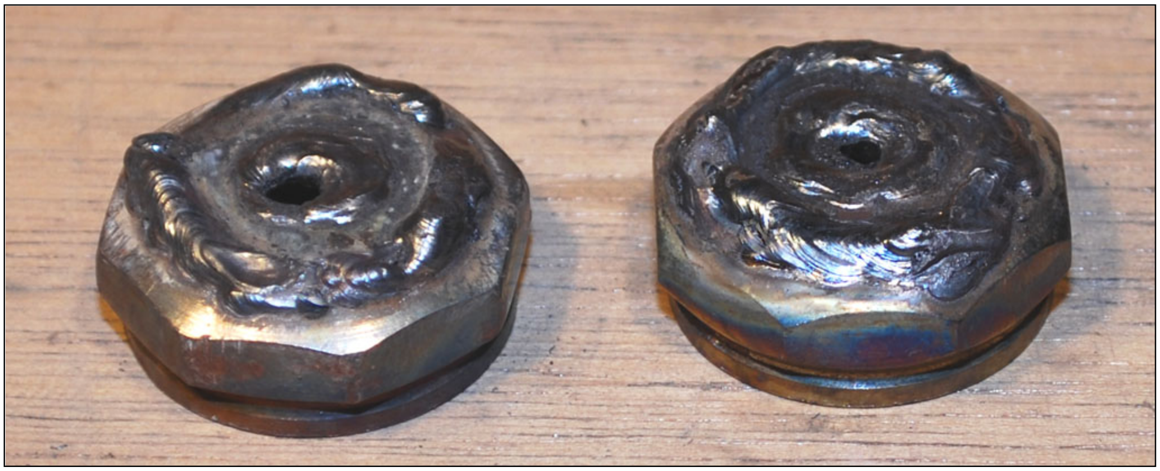

Figure 193 – Making caps for the steering

The top nuts that install on the steering system are open so that they can take a gooseneck in normal use, but this is no longer necessary on a trike. You could leave the open ends to later make fender or headlight mounts, or create a set of "trick" caps by welding washers over the top. About half of the caps I found were aluminum, but I eventually found a set of matching steel caps to weld.

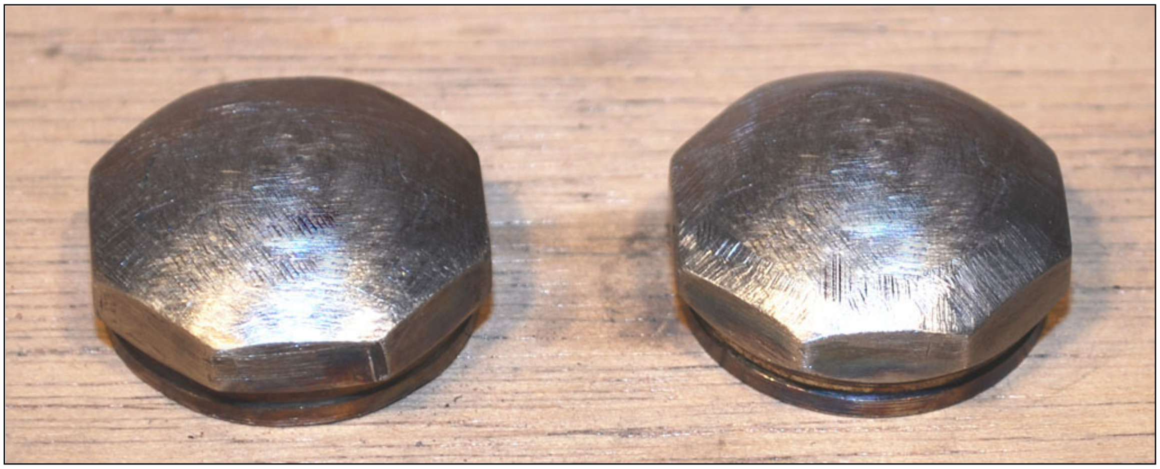

Figure 194 – A little grinder magic does wonders

Once the washers were fully welded and filled in the center, the flap disc was used to make the parts look like they came from a lathe (Figure 194).

Priming and Painting

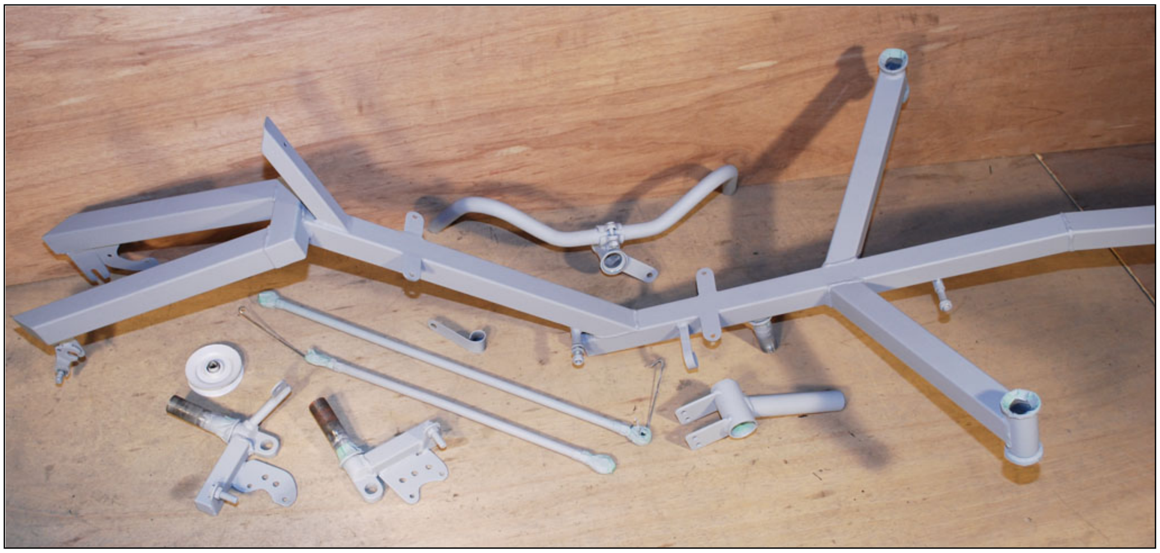

Figure 195 – Cleaned and primed frame

The next step is to finish and clean up any missed or bad welds, lightly sand the frame, then add a coat of primer. I only use department store spray cans, but usually get a very good paint job by following the instructions. What is not often mentioned is that primer should “cure” for a few days, and fresh paint should cure for up to a week before it becomes scratch resistant. Being impatient, I allow primer overnight, and give paint a full day before assembling a bike. The primed Warrior frame is shown in Figure 195.

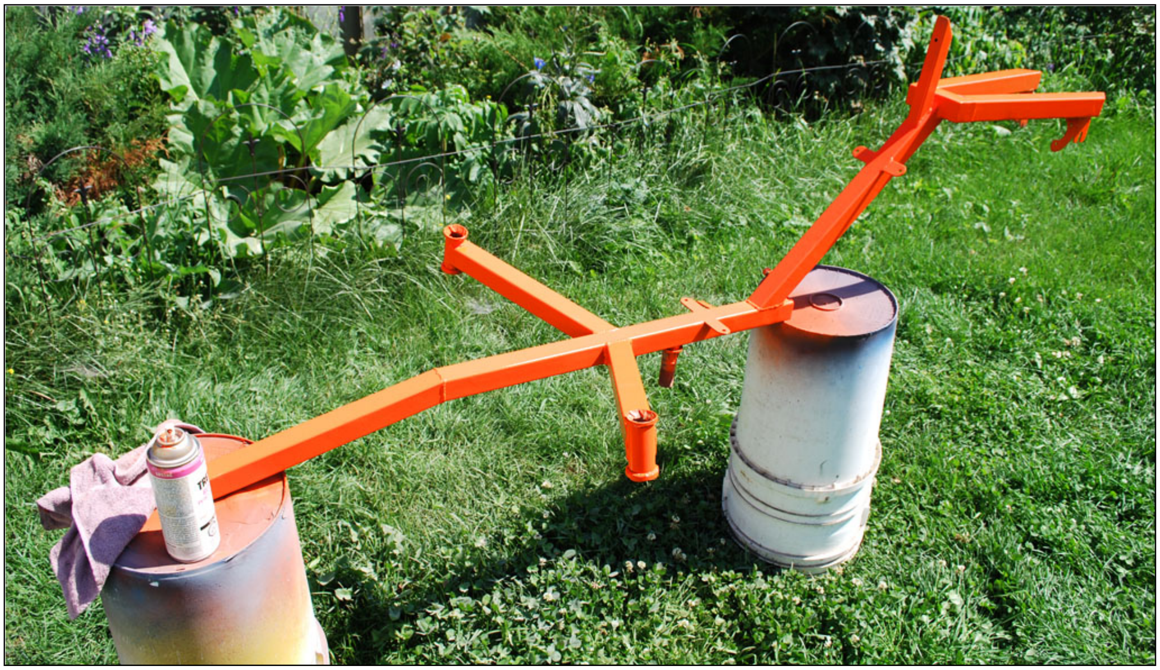

Figure 196 – My state-of-the-art paint studio

After the primer has cured for a night, I usually send my frames to a state of the art paint shop to be painted. This secret shop is located next to the garden in the back yard and comes equipped with several buckets to hold the frame. Figure 196 shows the brilliant orange coat after rattling the can for about half an hour.

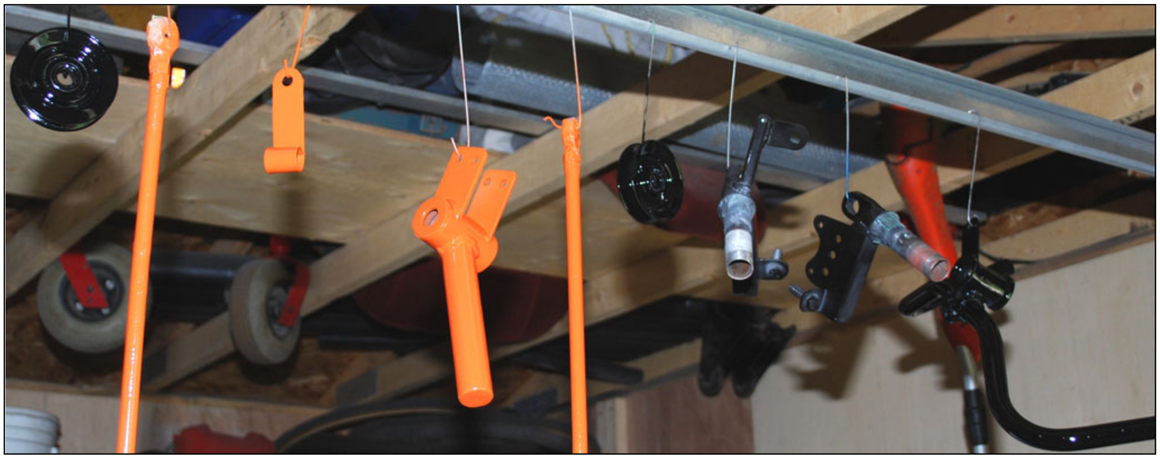

Figure 197 – Laundering the rest of the bits

The smaller parts hand inside the shop to dry while I work on painting the frame (Figure 197). It took two full cans of orange to coat the entire frame.

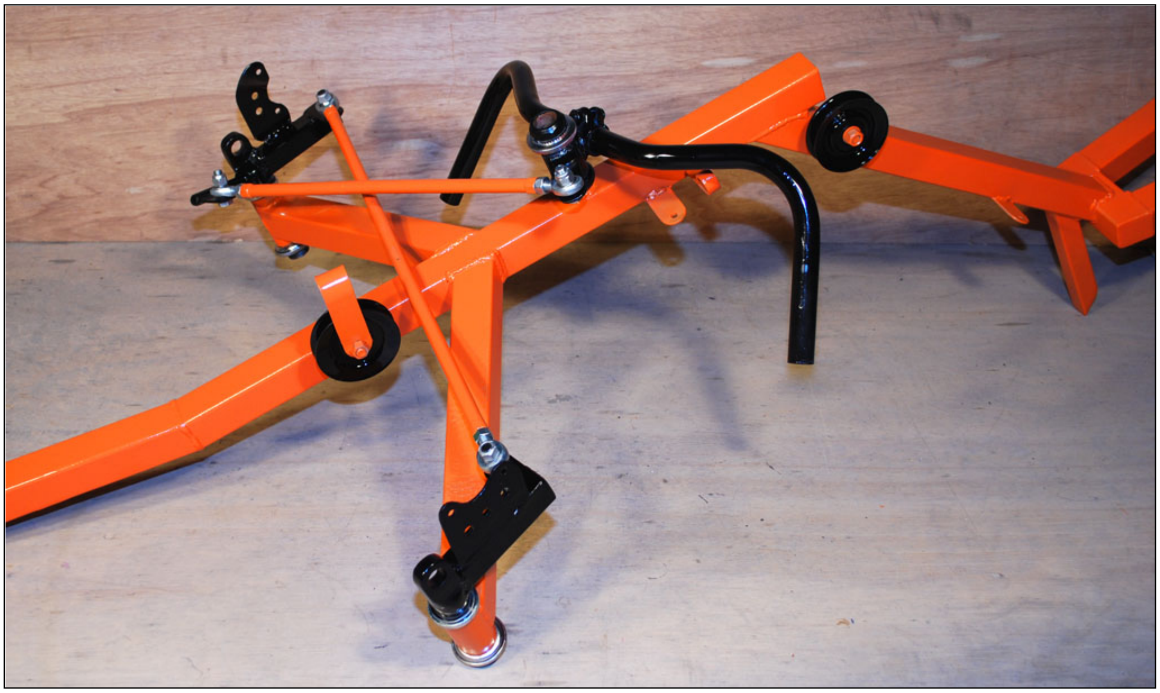

Figure 198 – Black and orange contrast

The black and orange contrast shown in Figure 198 really stood out. A hot racing trike needs a hot color, but I have overused orange and green on other bike projects!

Assemble the Parts

Steering

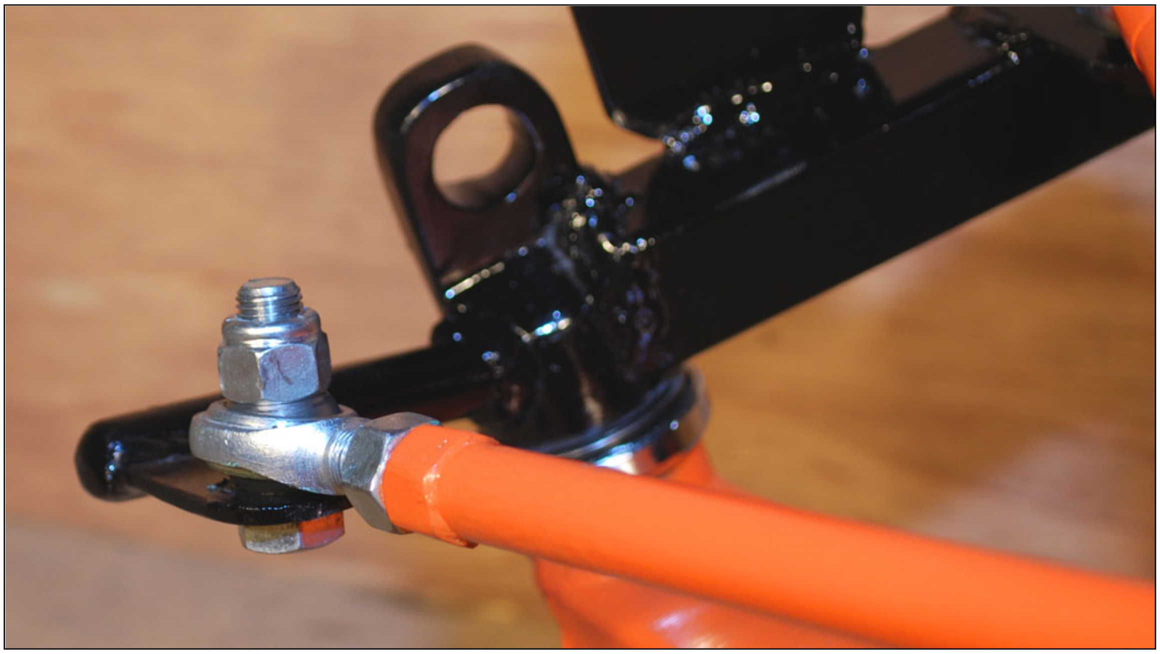

Figure 199 – Using lock nuts where it counts

When assembling the steering parts, including the main wheel nuts, I use either metal lock nuts or plastic lock nuts as shown in Figure 199. You should use a lock nut on any part where you might think, “Wow, what if that fell off?”

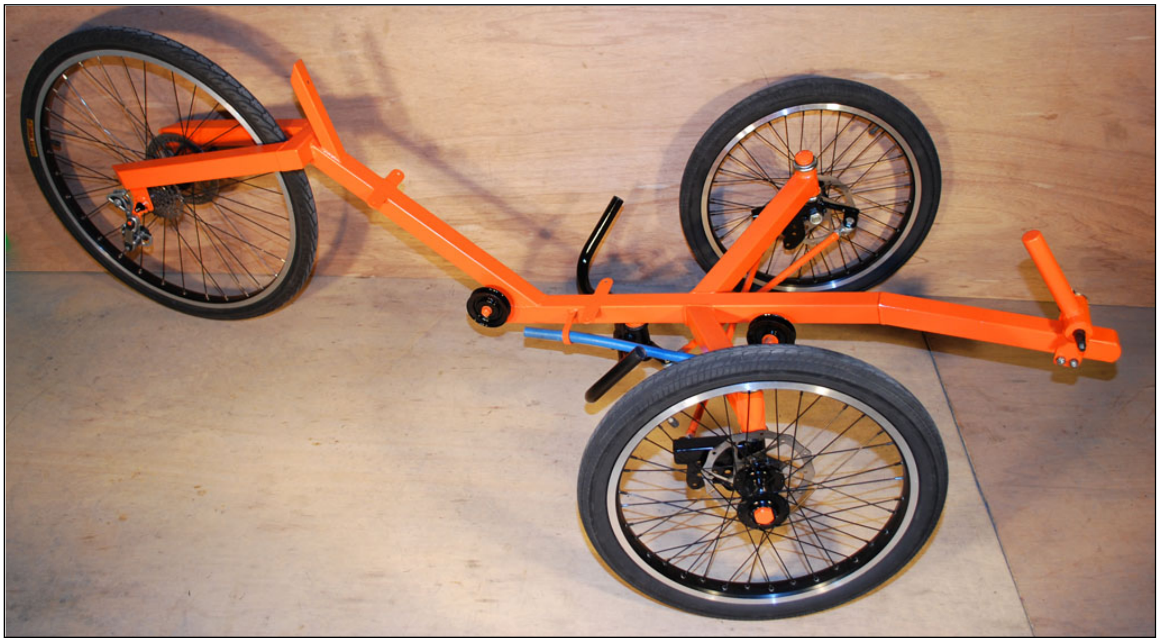

Figure 200 – Beginning the Warrior assembly

Since you built the thing, there is no assembly instruction manual! It does make sense to start with the main rolling components so you can move the trike around your shop easily. Figure 200 shows the wheels and steering parts fully assembles and greased where necessary. All bearings have been cleaned and greased as well.

Figure 201 – Grip shifters are a nice clean option

I normally like retro style shifting levers on all of my vehicles, but with such limited space and no gooseneck, the options were reduced to handlebar levers or grip shifters as shown in Figure 201. I also cut my handlebars very short as can been seen by the small grips, but like seating, whatever feels good is what you should use. There are no experts in this department. Brake levers also need to be positioned so that they do not strike the frame when the handlebars are fully turned. Figure 201 shows how close they come at full steer.

Brake Cables

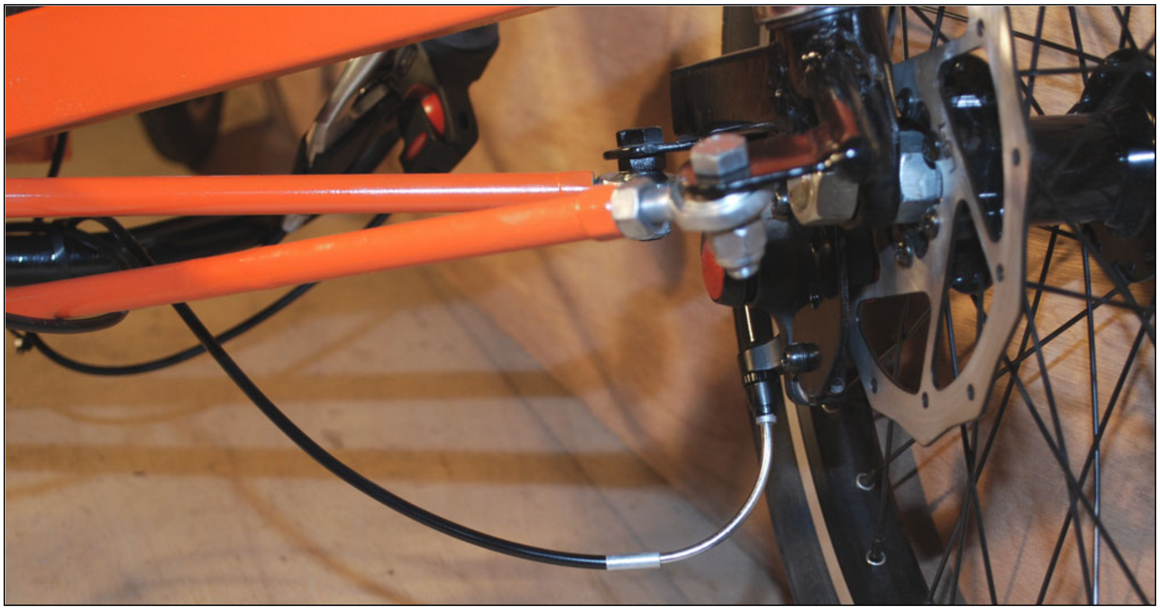

Figure 202 – Adding brake cables

I am no fan of adding cables, since they seem to look like a mess no matter how neat you try to be. The nice thing about the Warrior trike is that cables are mostly hidden under the seat, so the clean lines of the frame are not obscured by a mess of cables.

Cables should never be pulled tight or forced to make sharp bends, even when steering is maxed in either direction. The metal elbow shown in Figure 202 was taken from a side pull brake, and is a nice way to make a tight corner under the left side brake, which points towards the ground. If your budget permits, purchase all new cables, rather than messing around with used ones that may be stiff.

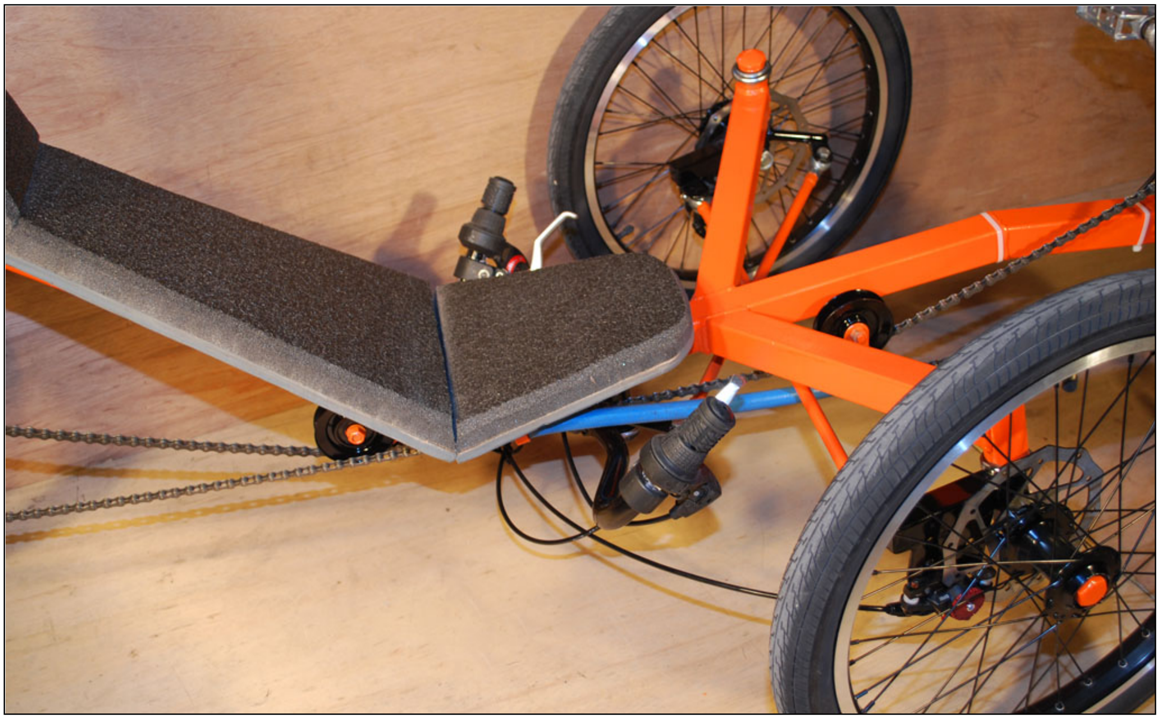

Figure 203 – Cables added and tied down

After adding all of the cables, a few tie wraps as shown in Figure 203 can help keep them cleanly routed. Ensure that no cable is pulled tight during steering, and then the chain does not rub on any of the cables. If you are installing 3 brakes, then you will have to source a small part called a cable splitter or find a dual cable brake lever to connect both front bakes to a single lever. Here are several available on the internet if you search for “dual brake lever”

Derailleur

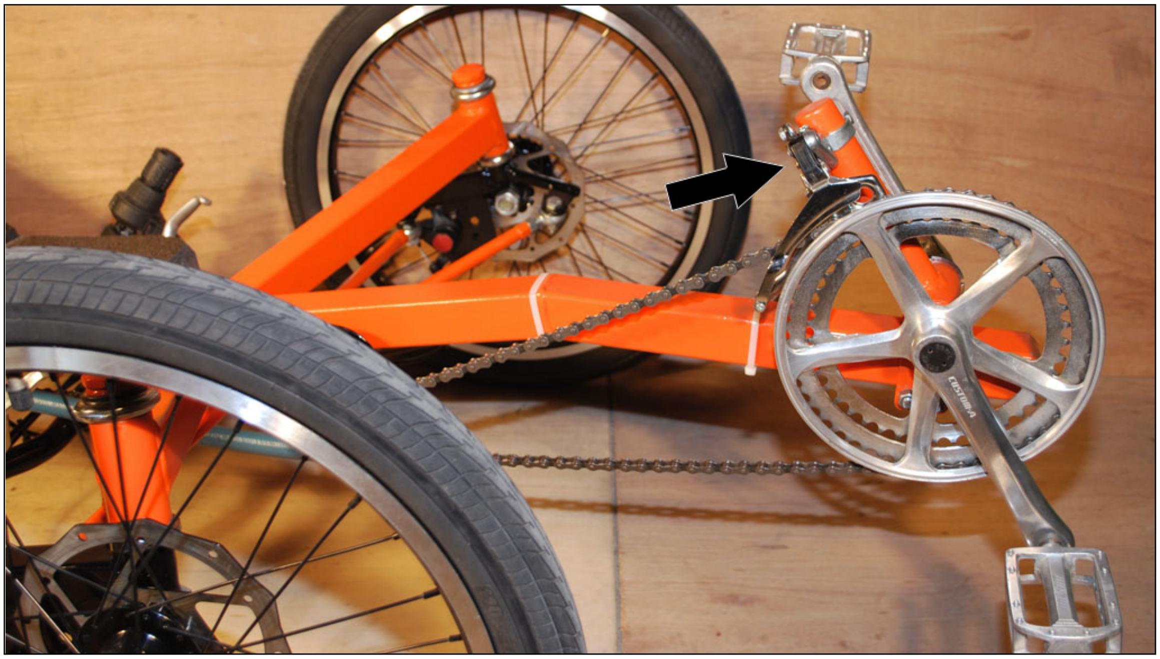

Figure 204 – Front derailleur adjustment screws

The adjustment of brakes is fairly simply; just set them so there is no heavy rubbing and so that they start to grip as the levers move about half-way. Derailleurs require a little more careful adjustment in order to set the minimum and maximum travel through the entire gear range. Both have a minimum and maximum adjustment screws, and these need to be set as you pedal and shift. Place the trike on a bucket so you can pedal the rear wheel. Figure 204 shows the general location of the adjustment screws for the front derailleur.

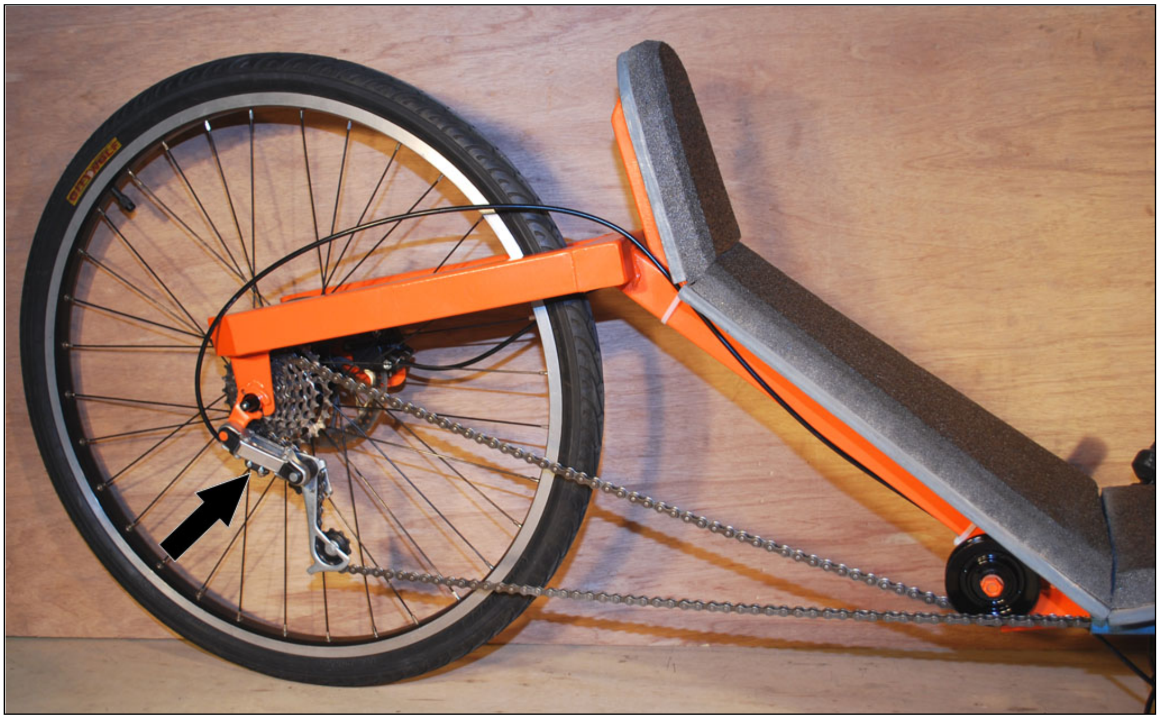

Figure 205 – Rear derailleur adjustment screws

The rear derailleur adjustment screws are normally found in the position shown in Figure 205. If these are not set correctly, the chain will either fail to reach all of the gears, or it will shift right off of the cluster, creating an annoying snag that will force you to stop and dirty your hands while out riding.

Show Off and Ride!

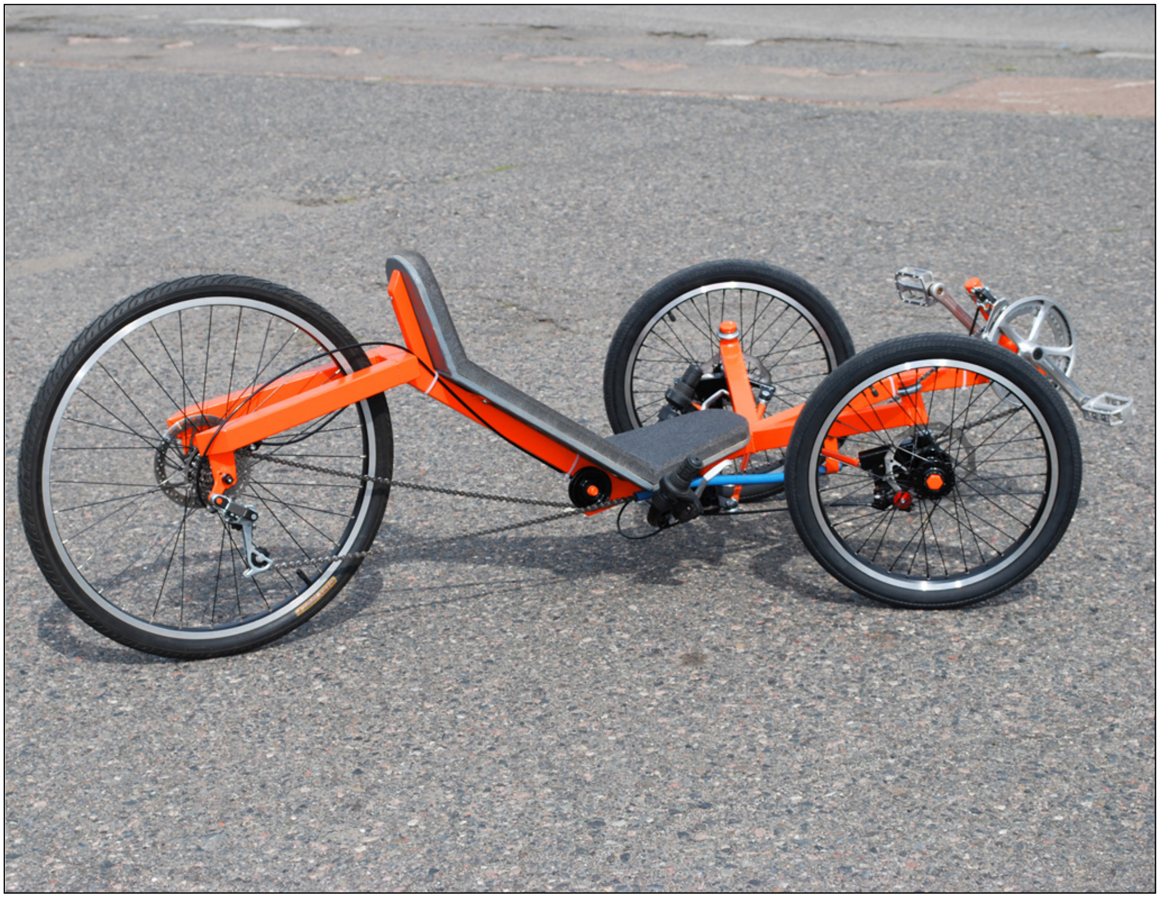

Figure 206 – The Warrior Racing Trike completed!

Considering it only weights 43 pounds loaded, and has all of the best features of any commercial trike, I would say it was certainly worth the effort! Not to mention, the total cost of parts was easily 10 times less than the cost of even a low end manufactured tadpole trike. Figure 206 shows what I ended up with after about a week of work in the garage – it’s hot!

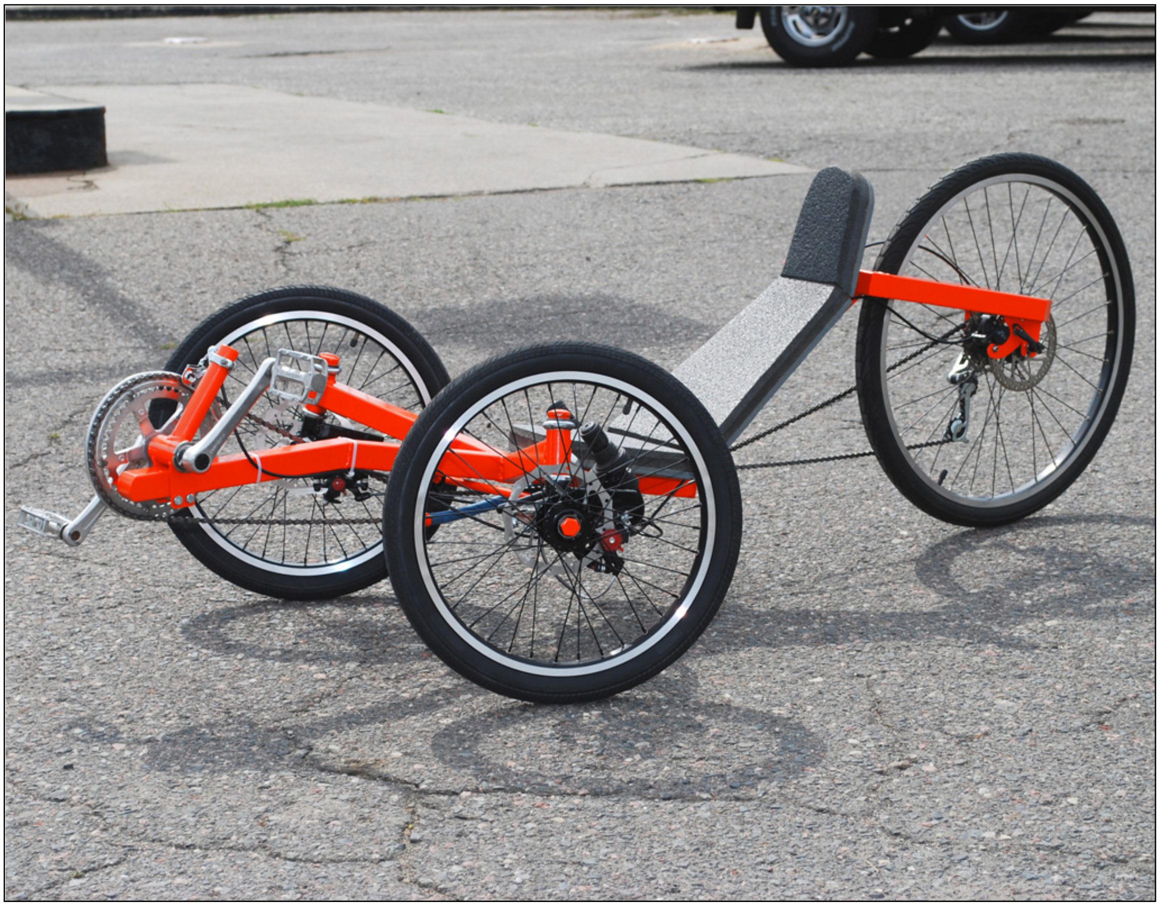

Figure 207 – Putting on a good modeling show

The simple lines of the frame along with the low seat and disc brake hardware scream out performance! If you took your time with the paint and detailing, people will ask you, “How much did that sweet ride cost?” instead of, “How long did it take to make?”

Even with the basic wood and foam seat, the Warrior (Figure 207) does not look homebuilt – it looks expensive!

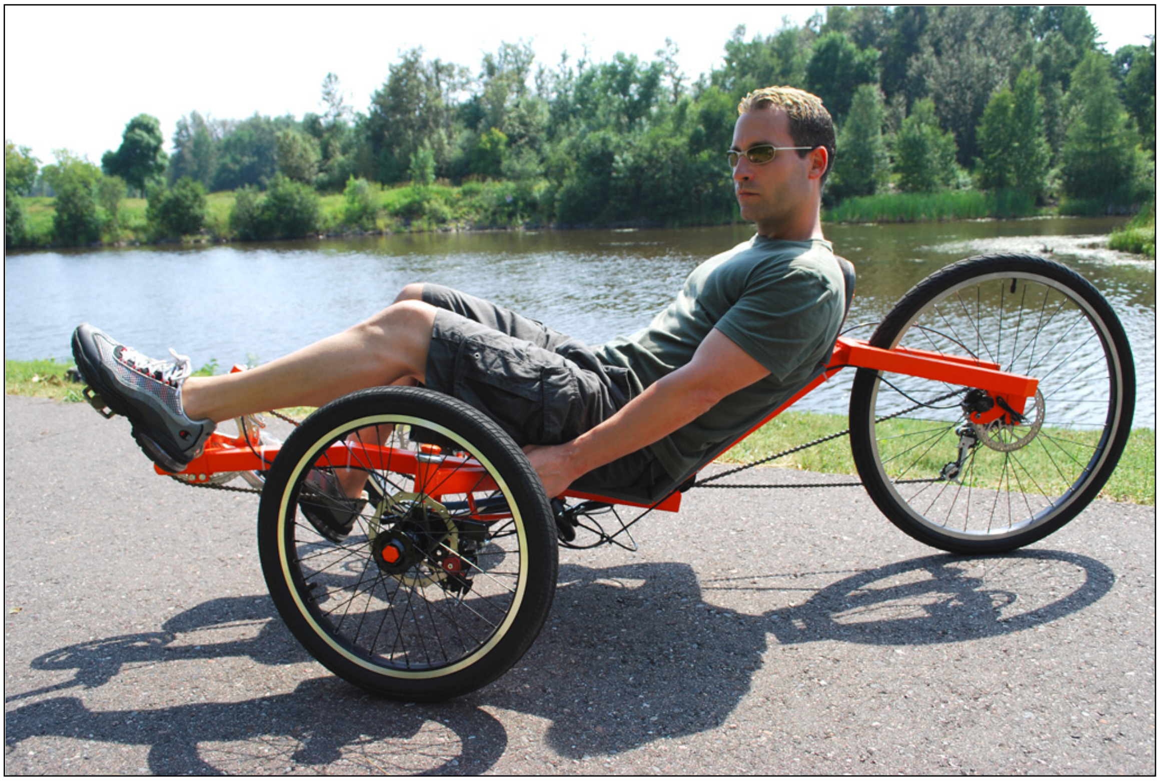

Figure 208 – Looking cool in the Captain's seat.

There is nothing to learn when taking your first test ride. What you will notice is how fast you can accelerate and how you don't have to slow down into the corners like you do on a regular bicycle. You also cheat the wind and have a lot more racing power at your disposal.

The reason you can sprint faster on a recumbent is because as you push on the cranks, your back is wedged up against the seat, making the limit your own physical condition. On a regular bicycle, if you push hard, you just lift yourself off the pedals, so you are completely limited to how much you weigh as being the maximum force delivered to the pedals. If you have had your first test ride then, I'm sure I don't have to tell you that the Warrior is a fast machine!

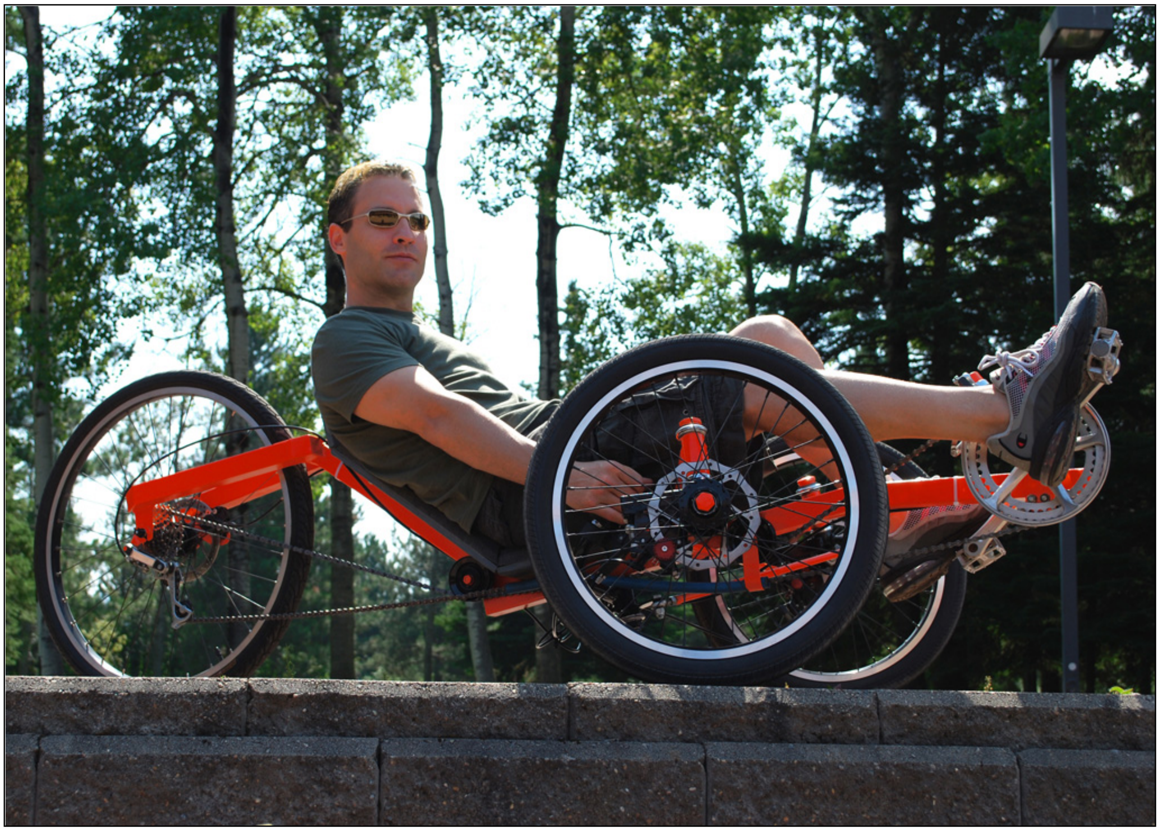

Figure 209 – Enjoying the view

The nice thing about touring on a recumbent is that you can stop and enjoy the view as if resting in a comfortable lawn chair. You also have instant speed at your disposal, and can draw a crowd wherever you go. I also enjoyed locking up only the rear brake on gravel roads to skid around corners, although this kind of abuse is not nice for your tires! Hill climbing was also amazing on this trike, as you can just hit a low gear and not worry about standing on the pedals just to stay balanced.

Figure 210 – Enough talk, I need to get back to the road!

Well, we hope you enjoyed carving a high performance racing trike out of a few hundred bucks worth of parts and some steel tubing! The feeling of accomplishment defies words when you first hit the road, and the look on people's faces when you tell them you made your ride is priceless.

Thanks for your support, and we hope your build progresses smoothly. With a little patience, a pile of scrap bicycle parts, and some trial and error, you can create just about any human powered vehicle imaginable.

There is plenty of room for modification on this project, so please send us your completed photos for the Builder's Gallery so that others can see what you have done. If you need any assistance or want an opinion on an idea, stop by our Support Forum and introduce yourself to our many creative fellow garage hackers.

Good luck on all of your projects. Have fun and ride safely.

Brad Graham and Kathy McGowan, Atomic Zombie™ Extreme Machines

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